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POWER

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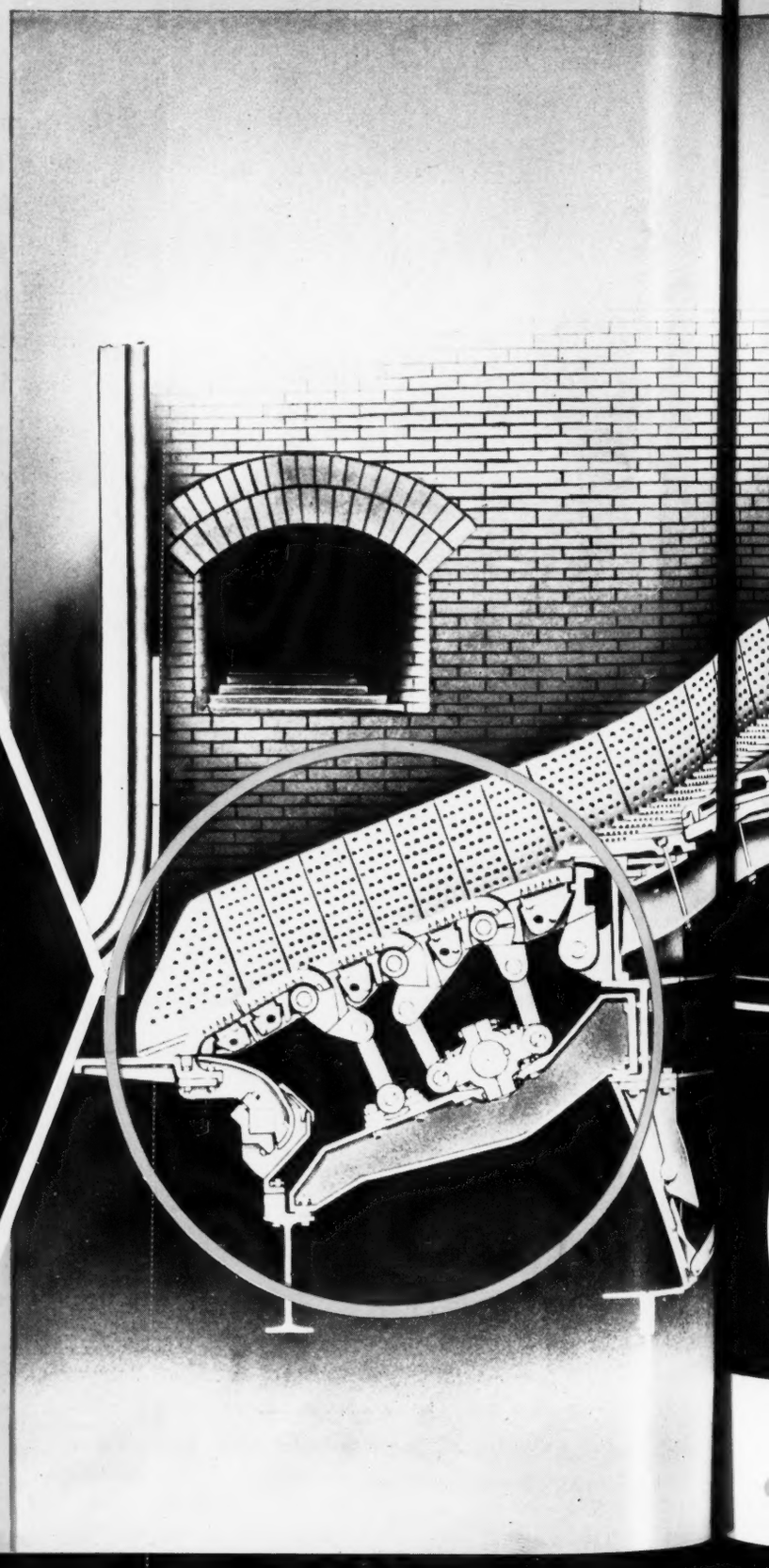

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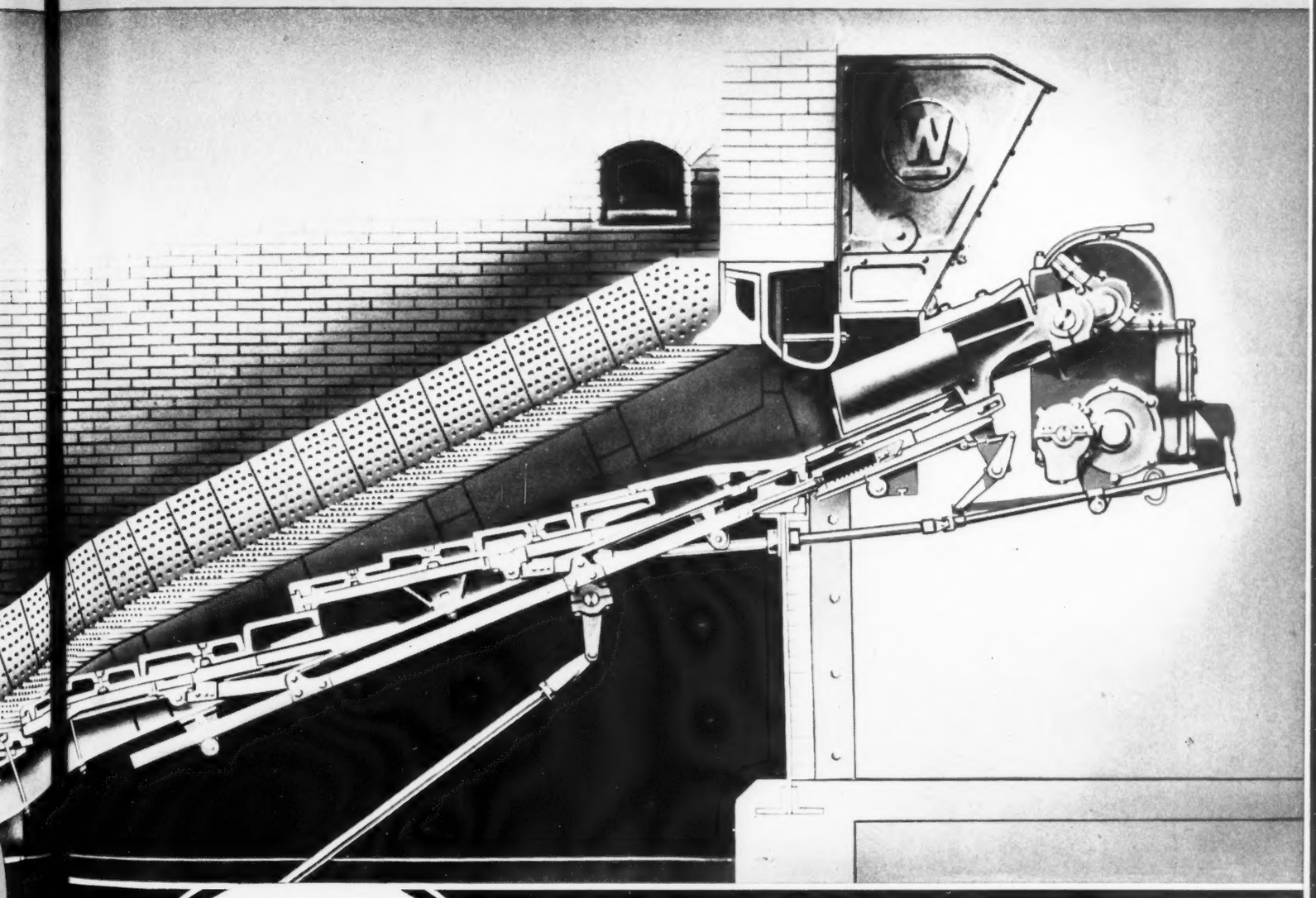

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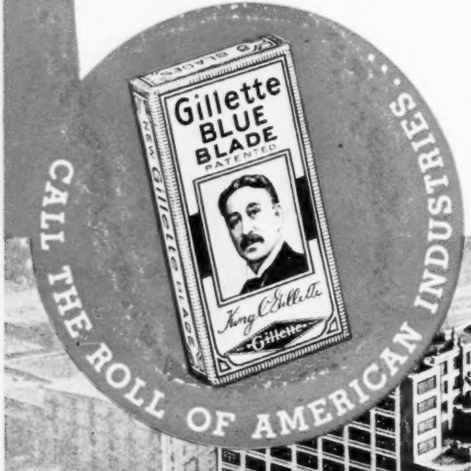

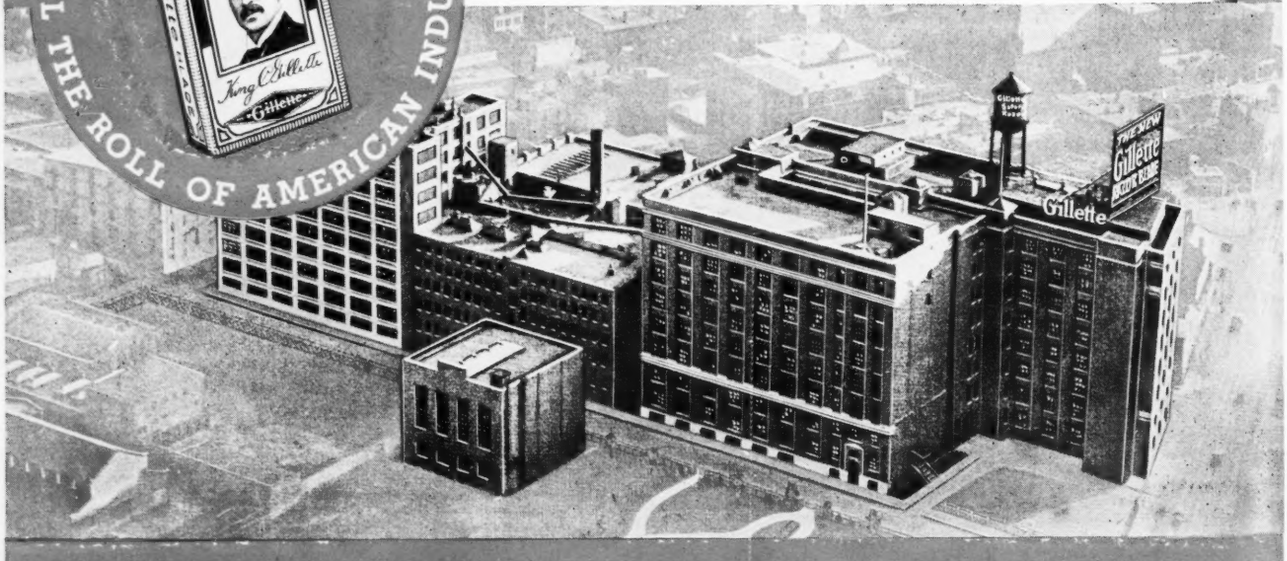

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POWER

Established 1882 P W Swain, Editor

Technique of Tomorrow

The seeds of a new machine age have been planted and the crop is rising everywhere. To get the picture, let's consider broad technical trends that have been speeding up for years, and will continue for years to come, if history is any guide.

As *Power* sees them, the basic long-term trends are these: new materials; new fastenings; new seals; better equipment design; higher pressures, temperatures and speeds; better efficiencies; growth of air conditioning; growth of diesels; growth of control and instrumentation; extension of electronic applications.

As a sample of today's progress in materials, consider metals. A book published by the American Society for Metals lists 4000 distinct ferrous and non-ferrous alloys. No end to metal progress is in sight. Yet these products of metallurgical genius are paralleled by the achievements of organic chemists with synthetic plastics, rubber, etc. Fluids, too, are materials, and in this field we constantly hear of new lubricants, new adhesives, new solvents, new refrigerants.

Many fail to grasp the real meaning of today's advances in seals and fastenings. This is basic progress, because engineering is largely a matter of "holding"—holding solid parts together, sealing fixed joints and sliding joints tight against fluid pressure. That is why even welding enthusiasts have not overstated the importance of modern welding achievements. Equally significant are the new flanges, glands, packings, valve seatings and other seals.

These new materials, and those new holding and sealing devices, are the building blocks of today's designing engineer. They tell him how far he can go. Their rapid and continuous development will help build tomorrow's prosperity. For example, power engineers have long sought higher pressures, temperatures and speeds to cut first cost and operating cost. Now they dare use them.

When initiative applies new knowledge to new materials, things happen fast. That is why equipment design is changing so rapidly today and will be on the double-quick tomorrow. The ultimate possibilities stagger the imagination.

Closely allied to these basic developments, yet with some special life principle of its own, is the geometric growth of diesels, air conditioning, instrumentation and control, electronic applications, and the extension of the packaged-unit idea to all kinds of power equipment. In each of these special fields production has been doubling every three to five years, with no slowing down in sight.

To sum up, we may describe the engineering era just ahead as the age of alloys, of synthetic products, of fluids, of fastenings and seals, of high temperatures and pressures, of high speed, of diesels, of air conditioning, of control and instrumentation, of electronic applications, of packaged equipment.

Knowing that this is ahead, we can better plan our operations as plant designers and operators, research men, manufacturers.

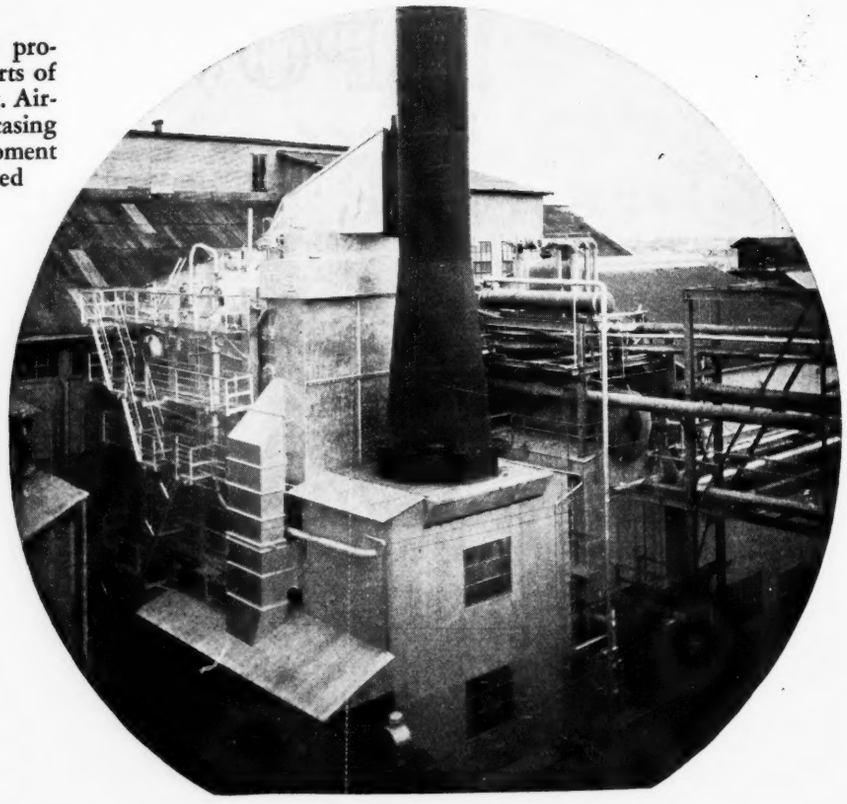


Fig. 1—Walkways provide access to all parts of outdoor boiler plant. Airtight steel boiler casing and exposed equipment are weatherproofed

Byproduct Power from Outdoor Boiler

440-lb, 750-F outdoor boiler serves 2000-kw non-condensing extraction turbine and sugar-refinery process-steam requirements

By JAMES T HILL
Supt of Power, Fort Bend Utilities Co

WITH the installation of a new outdoor steam generator and back-pressure turbine, the Sugar Land, Texas plant of Fort Bend Utilities Co supplies electric power, process steam and water to local industries and to street lighting and domestic consumers. Chief among the industrial plants served is the Imperial Sugar Co refinery.

In operation since June, 1937, the new boiler plant has demonstrated an efficiency of 82%. Byproduct power is produced at 4734 Btu per kwhr, chargeable to power generation after deducting process-steam use.

Power was formerly purchased wholesale, and steam at 110-lb pressure, saturated, was furnished by 12 boilers for process use. The old plant also contained two 500-kw condensing turbines for standby, supplied at 225-lb, 500-F by two Stirling boilers.

The new Riley boiler supplies 160,000 lb per hr of 440-lb, 750-F steam to a 2000-kw General Electric non-condensing unit. The turbine exhausts at 5 lb; process steam is extracted at 110-lb pressure. Normally, fuel is natural gas, but combination burners allow use of oil. The boiler is equipped with 16,000-sq ft Riley tubular air preheater designed for easy tube replacement. The entire boiler unit is outdoors, enclosed in an airtight steel casing sealed at points of drum and header movement. The only housing provided is for auxiliary motors, control equipment and operators' station.

Furnace floor is air cooled, built of two rows of firebrick laid over a course of Silocel brick on an 8-in. hollow tile. A steam washer is installed in the largest (60-in.) drum. Sturtevant forced- and induced-draft fans are vane controlled, driven by splash-proof squirrel-cage motors. Auxiliary supply is 2300-volts, 60-cycle. Combustion control is Bailey, set to hold 10% excess air by positioning the gas-fuel valve and fan vanes. Furnace pressure is held at 0.1-in. draft.

Two 4-stage, 400-gpm, Allis-Chalmers boiler-feed pumps operate at 3560 rpm. One is motor driven, one turbine driven. It has proved more economical to operate the motor-driven pump during normal-load periods. The steam-driven pump has a Copes Type SDS-2 governor set to maintain constant differential between pump-discharge pressure and boiler drum.

The Copes Flowmatic feedwater regulator maintains higher drum-water level at heavy loads. Its operation has been satisfactory. Continuous blowdown is flashed into the 110-lb process-steam system where 16% is recovered, then 14% of the remainder is flashed into the 5-lb system. After passing through a heat exchanger in the cold makeup-water line, blowdown drains to the sewer at about 90 F.

Steam enters the vertical closed feedwater heater from the 110-lb system. Condensate is returned to storage tanks. Feedwater (320 F) is about 40% condensate and 60% makeup, the latter taken from a 730-ft deepwell. A cold-process softener (caustic soda, aluminate and lime) operates at nearly constant rate and tanks allow about eight hours for reaction and

settling. After this, the water passes through pressure sand-and-gravel filters into a small storage tank. Nalco No. 8 is added to eliminate silica and prevent scale formation.

From the small storage tank, water is pumped through three heat exchangers (blowdown, vent condenser and charwater), in which it is heated to 160 F. Entering the primary heater of the hot softener, it comes in direct contact with 5-lb steam. After filtering and settling, water is pumped through an Elliott deaerating heater.

Condensate returned from the refinery is under 60-lb pressure and flashes to the 5-lb steam lines before entering the storage tanks.

The plant has been in operation since June, 1937, with no evidence of scale formation in boiler or heaters. The well water has a total hardness of 11 grains per gal. and a silica content of 1.4 gr per gal.

Two Swartwout pressure-reducing and desuperheating stations supply steam at 220 lb, 550 F and 110 lb, 350 F, respectively. The one supplies generating equipment in the old plant; the other regulates pressure in the 110-lb process steam supply. Steam from the turbine extraction point is mixed with that from the reducing valve before desuperheating.

Condensate is used for desuperheating, supplied by a separate pump at 250-lb pressure. If pressure falls below this value, a reducing valve cuts in boiler feedwater automatically. Flow of water to the desuperheater is controlled by two regulating valves operating in parallel. One of the valves passes a deficient amount of water for complete desuperheating and is regulated by reducing-valve position. The other valve, controlled by temperature, admits the small remainder needed to adjust steam temperature.

Exhaust-Steam Demand

Demand for exhaust steam at 5-lb pressure is relatively small and practically constant. The turbine-speed governor is connected to the extraction valve as well as the inlet-control valves by a 3-arm mechanism to increase the amount of extraction when greater electric load is called for. Exhaust-steam demand is satisfied first and regulated at 5-lb pressure. Any additional electric load is carried by increasing the flow through the first stages of the turbine by increased extraction. Remainder of the process-steam demand is then made up from the high-pressure steam header through the reducing valve.

It had been found more economical to operate the old plant during light-load periods. The steam rate of the condensing turbines is about 20 lb per kwhr and boiler efficiency between 70 and 75%. The old plant has been completely overhauled and its turbines renozzled for 600 kw each.

Valco, Inc, of Houston, Texas, were the engineers, A L Nelson, Boston, Mass, was consulting engineer, and M R Wood of Sugar Land acted for the Imperial Sugar Co.

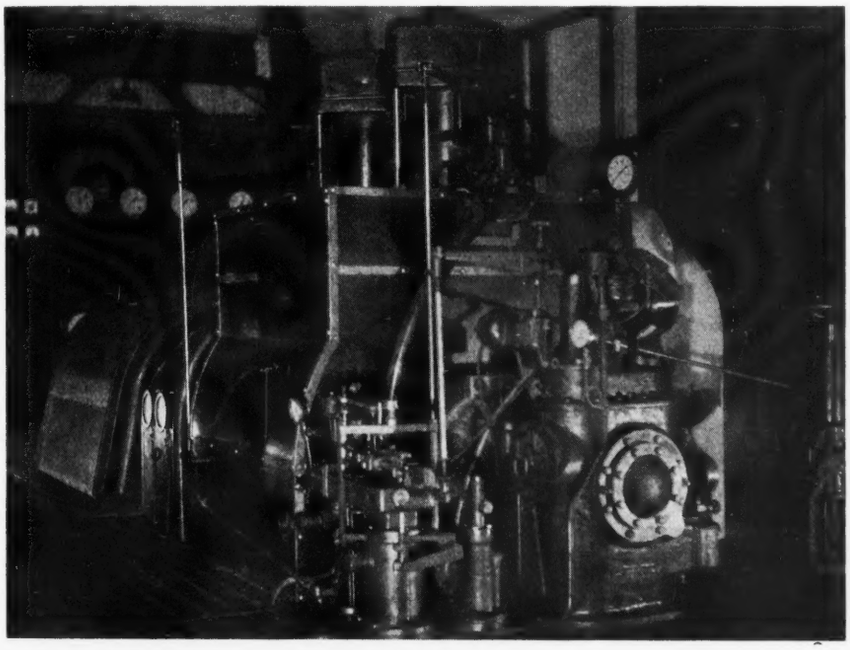


Fig. 3—2000-kw turbine controls extraction steam to suit electric load

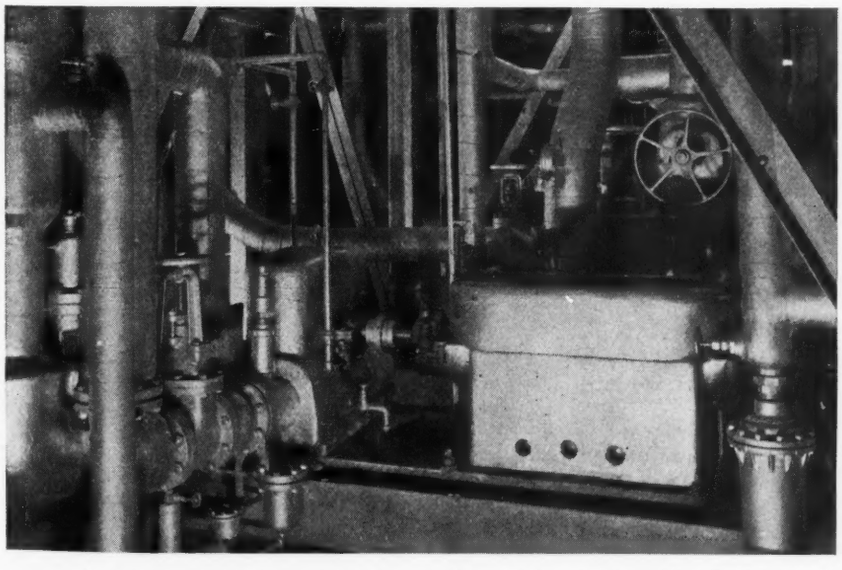


Fig. 4—Insulation nearly hides turbine-driven boiler-feed pump

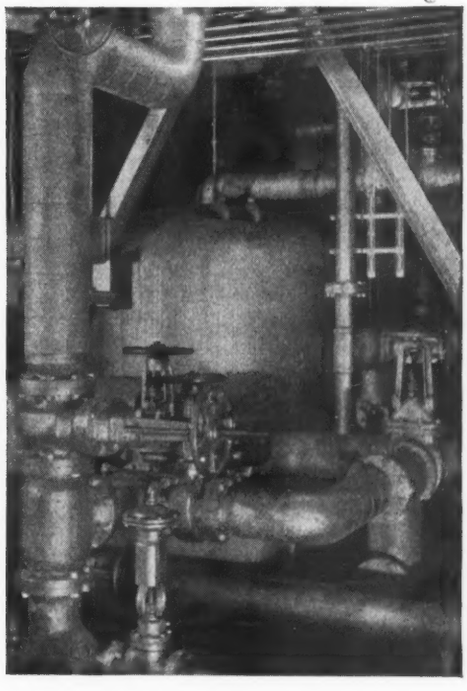


Fig. 2—Makeup, 60% of boiler feedwater, is taken from 730-ft. well. Filter and piping arrangement

Today's Diesel Practice—

Filters and Silencers

A survey of modern diesel plants develops practical installation arrangements for various engine and building layouts

BY ORVILLE ADAMS

AIR FILTERS and exhaust silencers are now used in nearly all diesel plants, but differences in layouts and operating conditions have thus far prevented the establishment of any standardized way of installing these auxiliaries. This general survey of a number of diesel plants in the Southwest shows how engineers have tackled the problems of protecting the air intake against dust and dirt and of effective silencing, and how ingenuity has made possible practical compromises with various building arrangements and conditions.

The primary idea in all cases is to connect the engine to the silencer or filter as directly as possible, with a minimum of bends and fittings; to have filters and silencers accessible for servicing, and to make the entire installation neat and unobtrusive. The method used will depend somewhat on size and type of engine and its application, but mainly on building design and engine layout.

In the simplest arrangement, suited to many industrial installations, particularly small, single-engine plants, the filter is attached directly to the intake manifold. The exhaust muffler is likewise installed on the engine, serving both as an expansion muffler and header when arranged horizontally, Fig. 1, a type known some years past as a "marine" type exhaust muffler. This is a 400-hp Bolinders engine in the Parker-Browne Co's ice plant at Fort Worth, Texas.

Taking air from the engine room is not entirely satisfactory, but normally the amount of air used is not large enough in relation to the total engine-room volume to interfere with heating of the building, and the inside location of the muffler compensates by throwing out heat. Water-cooled exhaust manifolds will take care of excessive radiation from the muffler.

The simplicity of this arrangement and the economies resulting from avoiding difficulties with pit construction, piping and filter housings, offset in many cases such considerations as appearance and efficiency. This is commonly the case in cotton gins, ice plants, small mills, and also in oil fields and on irrigation projects, where the entire installation may be outdoors.

An arrangement almost equal in simplicity and economy, and offering sufficient accessibility for cleaning and charging of filters is shown in Fig. 3, taken during construction of the Gainesville, Texas, water plant. Here the silencer is arranged horizontally, projecting through the engine-room wall to an exhaust pipe outside the building. A horizontal pipe runs from the silencer to the Cooper-Bessemer engine, to which it is connected by short risers from the exhaust manifold. A similar horizontal pipe, running through the wall, serves the air filter outside the building. Filters are

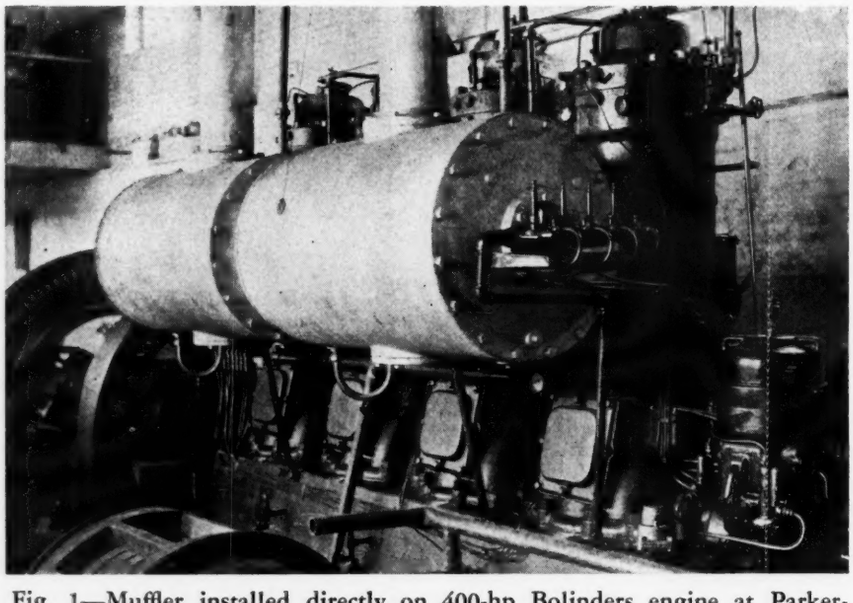


Fig. 1—Muffler installed directly on 400-hp Bolinders engine at Parker-Browne Co's ice plant, Fort Worth, Texas

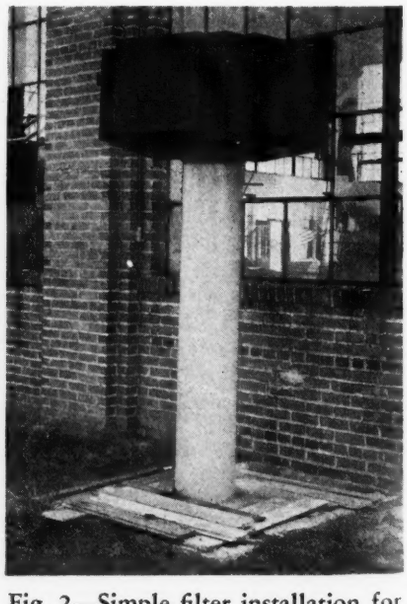


Fig. 2—Simple filter installation for 1000-hp De La Vergne

not housed and are accessible by ladder. A closely related arrangement mounts both silencer and filter inside the building with the filter in a horizontal line, or at the top of a vertical riser.

This general method of installation is found on engines of moderate rating. It can be suited to many conditions, and clears the engine without making either silencer or filter inaccessible for servicing. Ample headroom is required.

Forrest City, Ark.

Particularly in larger plants, it is desirable to take air from outside. A neat solution is illustrated in Fig. 2, which shows the filter for a 1000-hp De La Vergne engine at the Forrest City, Ark., municipal plant. The filter is just outside the engine room at a convenient height above the ground level. The intake pipe leads down into the ground, running under or through the wall of the building, then upward to the manifold. The intake pipe might also be connected to an air duct under the engine foundations.

This assembly results in a simple piping arrangement, clearing the engine room of headers and risers. Protection for the adhesive-impingement type filter is optional.

Under certain conditions it may be undesirable to locate air piping or ducts underground, either because of corrosion or water seepage. A layout with many of the advantages of that shown in Fig. 2, is pictured in Fig. 4. In this plant at Lubbock, Texas, three 125-hp engines are used as standby for a utility high line. Filters, inside specially-constructed houses, are accessible for cleaning through doors over which louvres and wire screen are placed to exclude windblown dust and sand. The air duct connects to the top of the housing, running through the engine-room wall to the engine-intake manifold. Exhaust enters a heavily reinforced concrete pit, the terminus of which is just under the silencers. This combination results in particularly good silencing.

Denton, Texas

A time-proven method of connecting filters and silencers is shown in Fig. 5, a view of the Denton, Texas, municipal plant. In this case, horizontal headers from the 1000-hp McIntosh & Seymour engine connect directly to the filter and the silencer, both of which are conveniently located. For protecting the filter against the weather, and likewise from windborne lint from a nearby cotton gin, a metal sheet covers the filter. The lower section of the frame is covered with fine-mesh wire screen. In this plant, there are five 1000-hp engines

Fig. 3—Filter and silencers on engine-room wall, serving Cooper-Bessemer engines at Gainesville, Texas, water plant

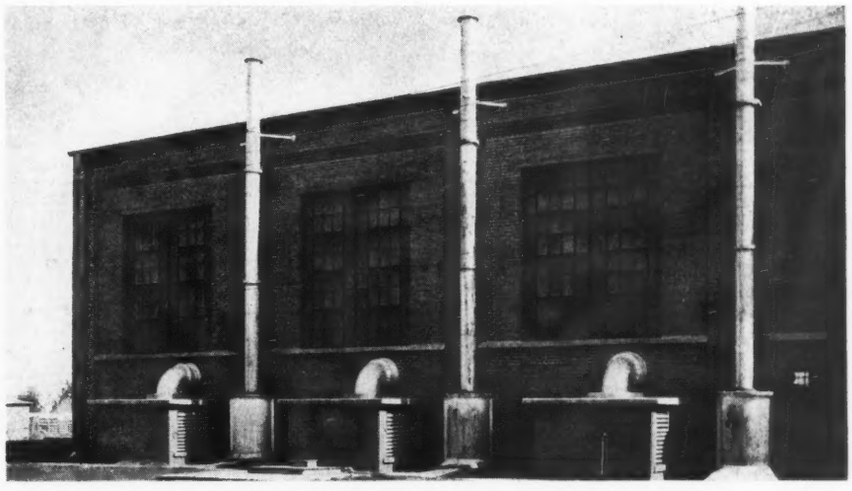


Fig. 4—Housed filters and silencers with underground exhaust pits at Lubbock, Texas. Three 1125-hp engines

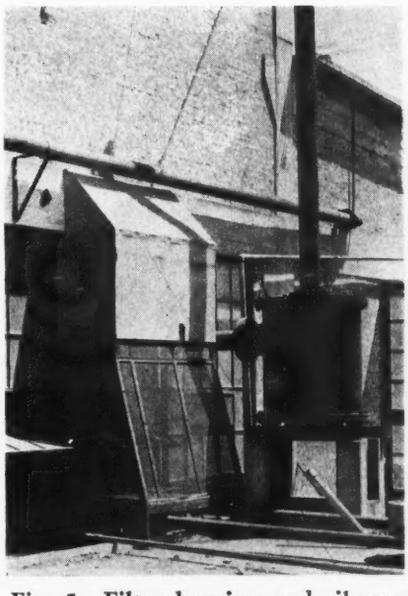


Fig. 5—Filter housing and silencer at Denton, Texas, municipal plant

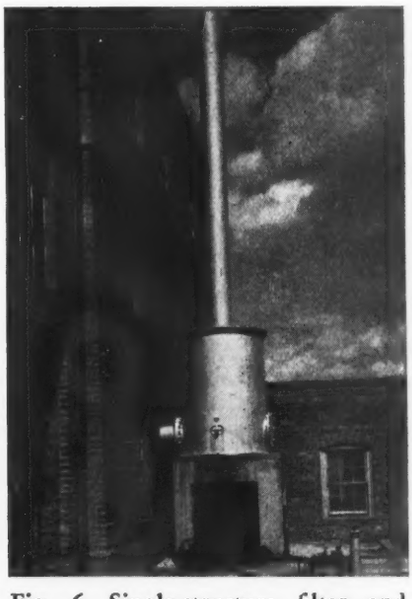


Fig. 6—Single-structure filter and silencer, serving 840-hp engine

each having a somewhat different arrangement of filter and silencer, depending on the shortest way out of the building.

The installation in Fig. 6, at Lubbock, Texas, combines, in one structure, filter housing and silencer foundation. The exhaust pipe connects directly to the silencer without turns. The 840-hp, 2-cycle engine is just inside the building wall, which keeps the length of exhaust and intake lines to a minimum. An underground duct of ample dimensions connects the filter chamber with the intake manifold.

Roof Filters

Where there are dust storms and prevailing wind velocities are high, as in the Southwest, there is often a definite advantage in locating the air inlet or the filter as high as possible. Roof locations are one means of securing the cleanest air possible and may offer the added advantage of short connections. A typical roof installation, Fig. 7, is filter-silencer arrangement for another 1000-hp engine (De LaVergne), in the Denton, Texas plant. The filter is protected by a sheet-metal housing with wire screen below. The muffler is located horizontally for better weight distribution, the inlet connection being from below. A flexible exhaust-pipe section is used inside the engine room to reduce vibration and noise transmission to the building.

In this case, the type of roof makes servicing filters and silencer relatively easy, but where such servicing is not feasible, the filter and silencers are sometimes placed just under the roof, with air and exhaust lines continuing through the roof. Or the filters may be put at a convenient height above the floor on a platform, with a somewhat longer pipe running out through the roof.

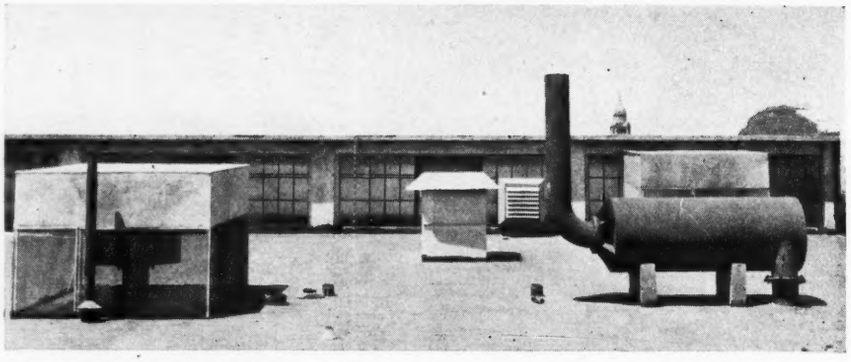


Fig. 7—Roof installation of filter and silencer. This is the plant shown in Fig. 5, but these auxiliaries are for another of the five 1000-hp engines, a De La Vergne

Fig. 8—Tall air-intake pipes, and housed filters, serve large Nordberg engines in Lubbock, Texas, municipal plant

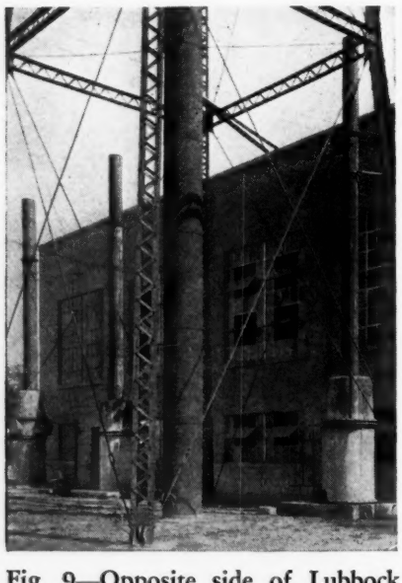


Fig. 9—Opposite side of Lubbock municipal plant, showing exhaust silencers and pipes

Another method of getting clean air. Fig. 8, is the filter and silencer installation for the Lubbock, Texas, municipal plant. The four Nordberg engines (1, 1250 hp; 2, 1500 hp; 1, 2000 hp) in this plant are side by side with air-intake ducts running below floor level to the outside of the building. There the ducts terminate in reinforced-concrete houses of ample size for filter arrangement in banks, necessary for large engines. Filters and air ducts are accessible through doors which are air-tight when closed. Vertical intake pipes extending 20 ft or more above the filter house, away from street dust, convey air to the filters. The ends of the vertical pipes have caps to keep water out and screens to exclude lint and windborne dust and trash.

Exhaust from these large engines is conveyed from the engine exhaust manifolds downward into exhaust pits which run to the opposite end of the power-plant building, Fig. 9, where the exhaust mufflers connect with the pits. Exhaust pipes are long enough to reach above the building, thus discharging fumes high in the air.

Although the route from intake pipe, through filters to engine and out the opposite end of the building through silencers and tall exhaust pipes, is more than 250 ft long, this system functions perfectly at 3200-ft elevation. Many difficulties and objections common to other arrangements are avoided and the installation is neat and attractive.

The men whom I have seen succeed best in life have always been cheerful and hopeful men, who went about their business with a smile on their faces, and took the changes and chances of this mortal life like men, facing rough and smooth alike as it came.—CHARLES KINGSLEY.

Don't Follow Pipe Size for Regulating Valves

A 2 in. pipe may be just right for the steam flow, but that dosen't mean you should choose the same size pressure-regulating valve. An expert considers the factors and the reasons why

By E T McCARTHY
Chief Engineer, Klipfel Mfg Co

SELECTING reducing-valve size to suit nominal pipe size, as for a gate valve, seems reasonable at first glance. Because the custom is firmly established and has many followers, one hesitates to indict it as uneconomic, inefficient and bad engineering. However, the correct selection of reducing-valve size is a thing apart from, and only remotely related to, the selection of pipe size. Of several factors which determine pipe size, only two apply to a reducing valve.

If a reducing valve is too small, the fact is obvious and a larger valve is installed. On the other hand, what if the valve is larger than necessary? While objections are not so readily apparent, bear in mind that an increase of 0.5 in. or 1 in. in valve size over the required size may increase capacity 100% or even 300%. Good engineers do not buy pumps, boilers or other equipment that much oversize. Aside from the higher first cost of the larger valve, there are definite operating disadvantages. An oversize valve works near its closed position, resulting in poor regulation, chattering, concentrated or localized wear, and excessive leakage.

If the valve disc is only 0.05-in. from its seat, a variation of 0.01-in. in the positioning of the disk by the control mechanism will cause a much greater percentage error in flow and regulated pressure than if the valve were smaller and operated at an average distance of say 0.25-in. from the seat.

A mistaken idea is prevalent that by using a large valve, velocity and its bad effects can be reduced. A little thought will show that for the same flow and pressure drop, the same area of port opening is required regardless of valve-body size. It is better to have this opening more nearly equal as to length and width rather than long and narrow.

Inspection of many used regulating valves shows that they have been operating at less than 25% of their maximum travel. Mechanical wear on the moving parts and wire drawing or erosion of seat and disk are deep and concentrated. It is obviously easier and cheaper to make and keep a small valve tight than a larger one.

These are the principle undesirable results of selecting too large a reducing valve. The next steps are: (1) to understand what factors determine flow through a valve, (2) to define valve capacity from a practical standpoint, and then (3) devise a method for calculating capacity. Most of what follows applies to reducing valves for water or air or other fluids as well as steam, and to other types of regulating valves such as backpressure, relief, pump governors, and float valves.

For Example

To remove the influence of a given pipe size in determining reducing-valve size, imagine a case in which there is no pipe. A high-pressure steam drum is to be connected by a reducing valve directly to a low-pressure receiver. Flanged openings will be provided in the drums to fit the valve when its size has been determined. To make the example specific, assume the pressures are 150 lb and 25 lb, and that 10,000 lb per hr of steam are required.

With no pipe size in mind, we can select valve size solely from information on pressures and capacity. If no information on reducing-valve capacities were available, a possible procedure would be to run a test to find out how large a hole in a thin plate would be required to pass 10,000 lb per hr of steam at the pressures indicated, and thus approximate the port area for a reducing valve.

Actually, plenty of information is available on steam flow through ordinary orifices and nozzles. From Napier's formula, we find that at an initial pressure of 150 lb, and a low side pressure of 96 lb or lower, flow

E T McCarthy started firm foundations for an engineering career at Cornell University. After a period as Assistant Professor at Georgia School of Technology, there came the World War in which Major McCarthy served in the Artillery Corps. As mechanical engineer with Sargent & Lundy, and later as president of Mercon Regulator Co, he has been associated for many years with power plants and their valve problems. Now chief engineer for Klipfel-Swan automatic valves; he advocates the use of scientific thinking in valve choice as expressed by Lord Kelvin, "When you can measure what you are speaking about, and can express it in numbers, you know something about it, and when you cannot measure it, when you cannot express it in numbers, your knowledge is meager and unsatisfactory. It may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the stage of a science."

through one square inch of orifice area will be about 8400 lb per hr. To pass 10,000 lb per hr would require 1.19 sq in. of orifice.

If we tried a reducing valve with this port area, we would soon learn that it had a capacity of perhaps 5000 lb per hr or less within its regulating range. A circular, thin-plate orifice as used in flowmeters, develops only about 61% of theoretical flow. Regulating valves, because of sharp edges, changes in direction of flow, and resistance and turbulence in the valve body, may develop only 20% to 40% of the theoretical flow based on measured port area. With good design, this figure may be as high as 70%.

Moreover, most reducing valves will not continue to regulate accurately as they approach wide-open position. For the pressure and flow conditions specified, a regulator would be selected having an *equivalent* port area of 1.19 sq in. or more, which corresponds to an *actual* port area of 6 to 1.5 sq in., or a 3-in., 2½-in., or 2-in. nominal-size valve. The actual area or valve size required to develop 1.19 sq in. of equivalent area depends on the design of body and ports and especially on effectiveness of control mechanism.

How do these valves compare in size with the pipes which would ordinarily be used for 10,000 lb per hr of steam at these pressures? To answer this we should know (1) length of pipe, (2) number and kind of fittings and valves, (3) initial steam pressure, (4) allowable pressure drop in pipe, (5) required capacity. Of these five factors affecting pipe size, only two apply in determining reducing-valve size, namely, initial steam pressure and capacity. Without going into a detailed discussion of pipe-size calculation, the 10,000 lb per hr would require a 3-in. pipe at the high-pressure condition. At the reduced pressure of 25 lb, volume of steam is four times as great and a 6-in. pipe would be required to keep velocity about 10,000 fpm. Larger sizes might be chosen if the pipes were long or a small pressure loss was allowed.

In addition to (1) initial steam pressure, and (2) capacity, which apply also to determination of pipe size, we need to know in selecting valve size, (3) low-side pressure if it is above 58% of the initial *steam* pressure, or above 53% of the initial *air* pressure, or merely the pressure drop in the case of liquids, (4) accuracy of regulation required, and (5) type and design of the valve itself. These last three factors clearly have nothing to do with the pipe.

Inasmuch as calculation of reducing-valve size and pipe size are based for the most part on different data and different physical principles, *it is only a coincidence if nominal pipe and reducing-valve sizes happen to be the same,* when each is properly determined. In general, the reducing valve may be smaller than the supply pipe because velocity through the ports, which depends on pressure drop, is much higher than is considered good practice for the pipe. For steam, critical velocity is reached when the reduced pressure is 58% or less of the absolute inlet pressure. This velocity is about 50,000 ft per min. Even if the equivalent port area were half the area of the pipe, velocity in the pipe would be 25,000 ft per min, which is much too high. If pressure drop through the valve is rather small, as in the case of low-pressure gas and steam valves, resulting velocity in the ports will be much lower than critical velocity and the reducing valve may need to be larger than the connecting pipe size.

For water, the velocity is $V = 12.2\sqrt{pd}$, where pd is the pressure drop through the valve and V the velocity in ft per sec. With only a 9-lb pressure drop, velocity in the valve ports is 36 ft per sec. Here again, if equivalent port area is half the pipe area, resulting velocity of 18 ft per sec is too high for the pipe. Consequently, reducing valves for liquids also can usually be smaller than the pipe.

A reducing valve is expected to maintain a constant low-side pressure regardless of changes in demand for steam or changes in initial pressure. Some cases require close regulation, perhaps within 1%, while for others a 25% variation may not be objectionable. Only that part of the valve capacity within the limits of regulation is useful. The fineness of pressure control required must be known before the *useful* capacity of a given valve can be stated.

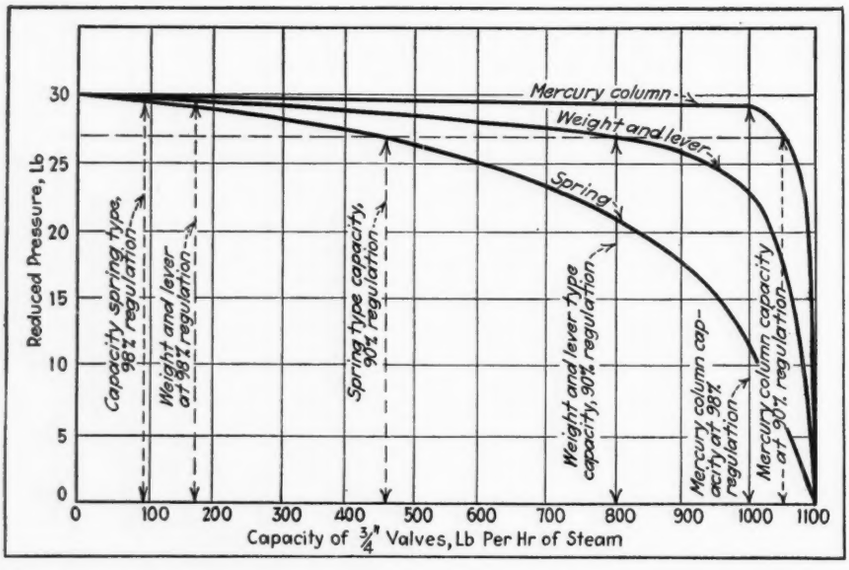


Fig. 1—Relative capacities of three types of reducing valves having identical bodies and ports. Capacity depends on (1) drop allowed in low-side pressure and (2) type of control

Control Characteristics

For example, if a valve is required to deliver steam at 30-lb maximum, with a pressure variation not over 10%, then only the quantity the valve and its control mechanism can deliver between 30-lb and 27-lb pressure is useful. The curves of Fig. 1 show the characteristics of three types of control mechanism applied to valves having identical bodies and ports. The "wide-open" position corresponds to 1100-lb-per-hr capacity on the scale, but the spring-loaded type delivers only 450 lb per hr within the 10% regulating range. The other two types can supply 800 and 1050 lb per hour respectively within the same range.

It may not be clear at first glance why valves having exactly the same bodies and ports, but different operating mechanisms, have different capacity ratings. If we were to define capacity as the rate of flow under certain inlet and outlet conditions *when the valve is held wide open,* then of course, the capacities of such valves would be equal. Such wide-open capacities have no practical meaning. It is assumed that reducing valves, once set for a given pressure, are not subject to further manual adjustment. If adjustments have to be made to keep the reduced pressure within the prescribed limits, the valve

is hardly an automatic reducing valve in the accepted sense.

In a spring-loaded, diaphragm-type valve, represented by the lowest curve of Fig. 1, loading force exerted by the spring decreases and the working or effective area of the diaphragm increases as the valve opens, causing a rather rapid drop in low-side pressure as the flow increases. The middle curve refers to a lever-and-weight-loaded, diaphragm-type valve in which the loading force is constant but effective diaphragm area increases as the valve opens. The top curve is for a mercury-column-loaded, diaphragm-type valve. The mercury-column type has much superior regulation.

A fair and practical comparison of valves must be based on actual capacities within *usable range of variation* in low-side pressure. Yet, how can a purchaser make such comparisons when manufacturers' catalogs express capacities on different bases with little or no mention of percent regulation or variation from normal at the stated capacity.

At the risk of repeating the obvious, we suggest that reducing valves for automatic control of fluid pressure be rated according to their *equivalent* port areas at 90% regulation. Rated flow capacity then becomes, for any valve, the *equivalent* port area multiplied by the theoretical flow through one square inch area for given pressure conditions. The equivalent port area must be obtained for each size and type of valve and control mechanism by experiment. The theoretical flows per sq in. for ordinary fluids can be readily calculated and shown by tables or curves.

It is felt that this method of rating and calculating the capacities of regulating valves provides a fair basis for comparison. It is simple and involves only the multiplication of a theoretical flow taken from standard tables by a factor, representing equivalent port area, to be supplied by the manufacturer for each size and type of valve.

Let Scrap Take the Rap

By HARRY M SPRING

BOILER SURFACES have been taking it on the chin from oxygen in the feedwater for a long time; deactivation, in which scrap iron takes the beating before the water gets to the drum, is a sound answer to the problem in many cases. This treatment is fully described in "Corrosion—Causes and Prevention" by Dr. Frank N Speller. Briefly, deactivation is accomplished by passing oxygen-bearing water over large surfaces of scrap iron, where the oxygen unites with the iron to form ferric-hydroxide rust. In this manner, waste metal is rusted to use up a considerable part of the dissolved oxygen, and the water, relatively oxygen-free, flows on to boiler.

In a large laundry plant, with water-tube boilers of the bent-tube type, pitting in boilers had been found up to about two years ago. The boilers operated at 200 lb and makeup approximated 15%. Returns from low-pressure processes bore considerable amounts of free oxygen, and makeup was far from zero oxygen. It was found, after about six years operation, that active corrosion and pitting was taking place at the drum and head surfaces. An open feedwater heater was used, operating at 208–212 F, so part of the oxygen was mechanically eliminated. As the pitting continued, it became evident that the oxygen content of the water was too much for the heater to remove effectively. It was then decided to try deactivation.

A discarded storage tank, 54 in. x 8 ft, no longer fit for high-pressure service and provided with a manhole, was installed directly below the feed-heater (Fig. 1). A ½-in. mesh steel strainer was placed over the feed pump suction, which passed through the tank head in a boiler-type bushing. The suction end was kept about one foot from the tank bottom to prevent rust accumulations from building up into it. A 4-in. drain and gate valve was provided every two feet along the tank bottom and a 2-in. line was installed at the top for flushing. Feedwater from the open heater was piped to the top of the tank at the end opposite from the suction.

Internal surfaces of the tank were wire-brushed and given three coats of Portland cement wash, for protection against corrosion. The tank was then filled through the manhole with about two tons of old scrap iron—pipe, fittings, etc, in large pieces.

Six months after oxygen removal was started by this process, the boilers were opened for inspection. All active pitting had ceased. The scrap is corroding and pitting rapidly and replacement with larger pieces will probably be necessary soon to maintain the exposed area of the surfaces and to prevent pieces becoming so small they present a hazard to the feed pump. Practice has shown that the rust should be flushed out about every 1000-hours operation in order to prevent effective metal surfaces from being embedded in loose rust, and clogging of the drain lines.

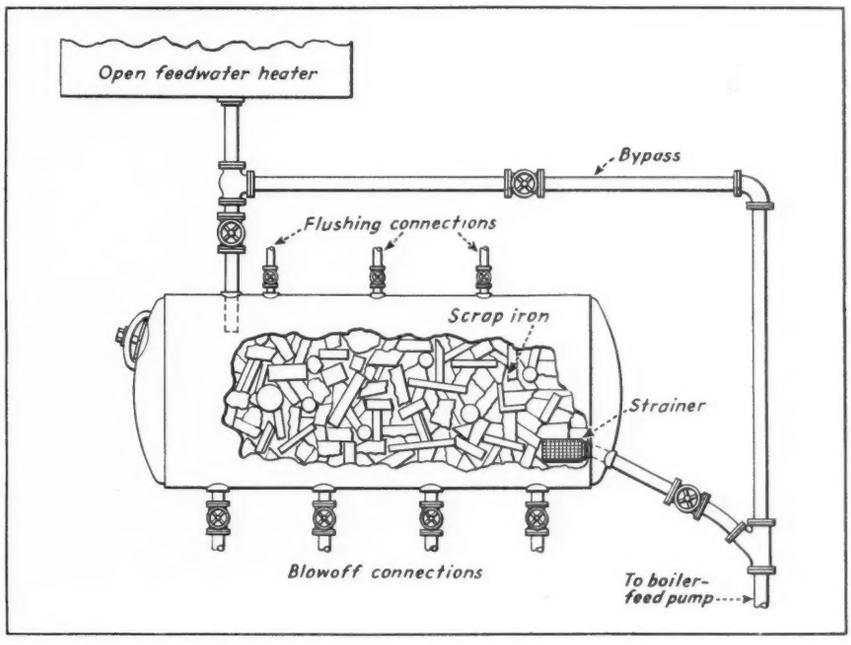
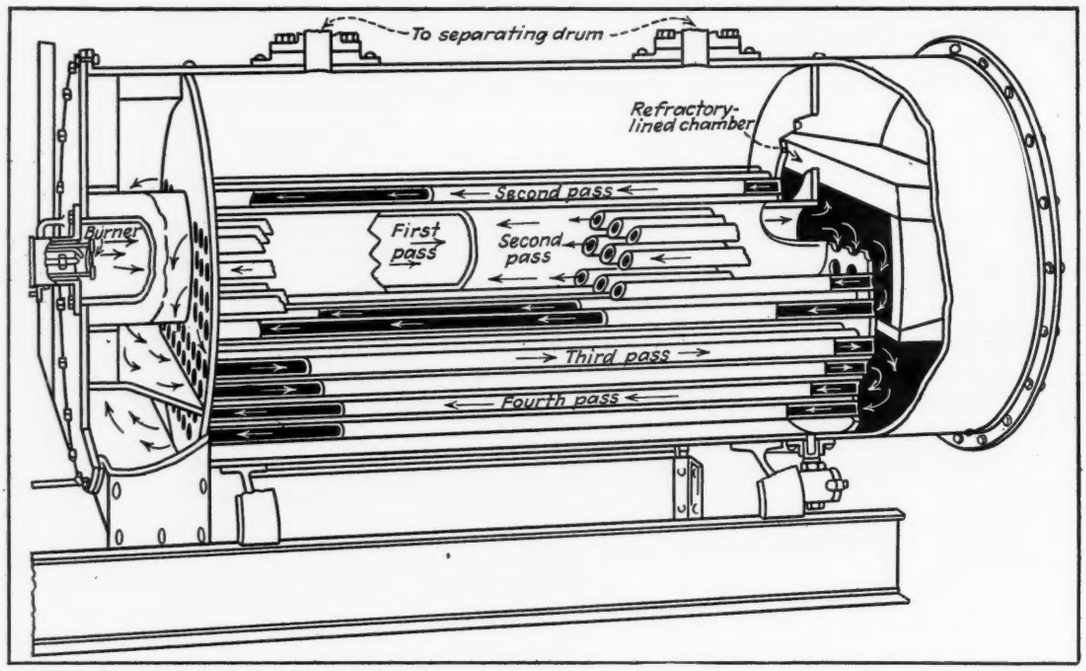


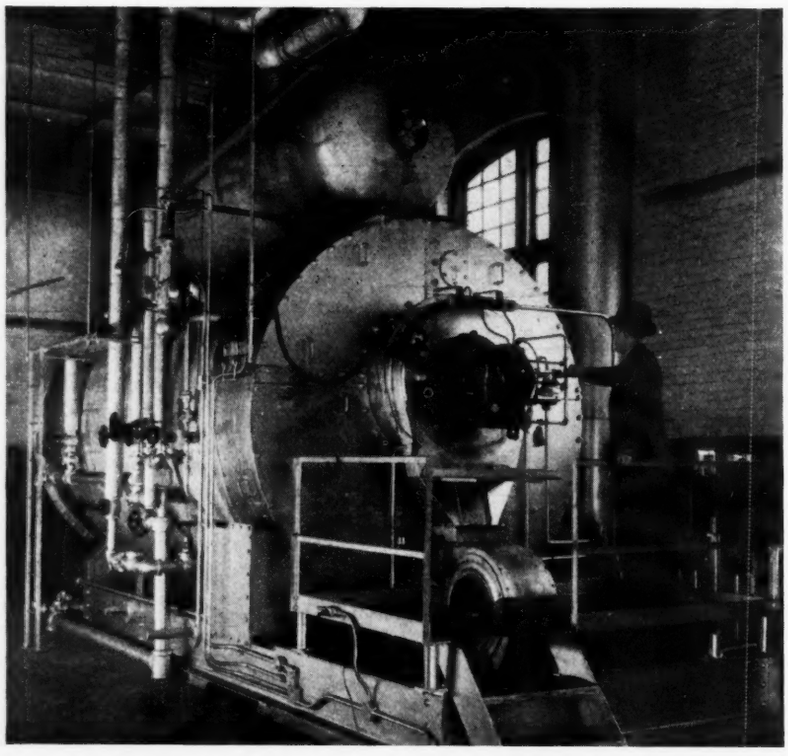
Fig. 1—Arrangement of deactivating tank



Section through boiler illustrating path of gas and general arrangement of parts

"Packaged" Boiler for Nicholson File

Need for additional steaming capacity met by installing oil-fired, 17,000-lb-per-hr factory-assembled unit



New "packaged" boiler unit, showing heavy-oil burner and controls

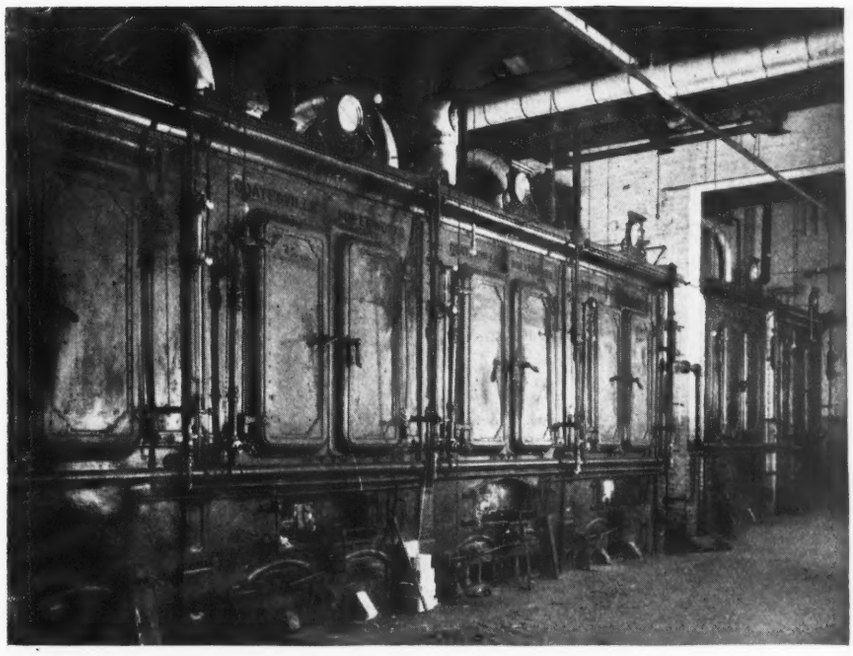
WHEN Nicholson File Co decided that more steaming capacity was needed for their Philadelphia plant, a thorough study of the field was made to select a modern, efficient unit which could set a pattern for possible future boiler-plant modernization. The boiler installed is another example of a trend in the power field, the idea of the "packaged" unit. In this case, boiler, oil burner, and auxiliaries were bought and delivered as a unit, mounted on a structural steel base, ready to operate as soon as proper piping and electrical connections were made.

The new boiler takes its place with six Coatesville hrt boilers, one battery, of four boilers, installed in 1899, and the remaining two boilers in 1910 and 1917. All boilers were converted to oil firing about eight years ago. Each has about 1500 sq ft of heating surface. Steam, at 110 lb, is supplied to an 800-hp Watts-Campbell Corliss engine, a steam-powered air compressor, steam-driven pumps and to the heating system when required. Normally, building heating needs are met by exhaust.

Essentially a fire-tube boiler of the marine type, redesigned for efficient oil-burning operation, the new "Oilbilt" boiler is rated at 17,000 lb per hr and is built for 150-lb steam pressure. An efficiency of 80% is guaranteed by Cleaver-Brooks Co, of Milwaukee, the manufacturers. Contributing to this high efficiency is the 4-pass downdraft arrangement of passages giving long gas travel. As shown in the drawing, the burner is set in the water-cooled central flue, from which the gas passes to a refractory-lined chamber at the rear. Here the gas stream divides, and flows toward the front of the boiler in two paths, a bank of tubes on either side of the central flue forming the second pass. The third-pass tubes are below and extend across the width of the drum. Gas from this pass exits into an unlined chamber below the refractory-lined chamber at the end of the first and second passes. Flow in the fourth pass, at the extreme bottom of the drum, is again forward and the products of combustion, cooled to less than 500 F, are carried off by a vent pipe rising vertically at the front of the boiler.

Steam leaving the water surface in the main drum rises to a dry or separating drum above, insuring a constant supply of dry steam. This auxiliary drum and the middle portion of the main drum are insulated.

The horizontal rotary oil burner is equipped with special controls and a blower for primary and secondary air, designed to proportion air and oil in the correct ratios for all loads from 20% to full rating, resulting in a CO_2 range of 13.5 to 14%. The burner controls regulate its operation on the high-low flame cycle, in accordance with boiler pressure, and a complete set of protective devices takes care of motor overload, flame failure, or low water. Ignition is by a manually-operated gas lighter. A motor-driven gear pump supplies oil under pressure, and oil temperature is held at about 180 F by a thermostatically-controlled steam preheater.



Existing boiler equipment; six oil-fired Coatesville hrt units

No Stack Needed

Since all draft requirements are met by the blower, which is V-belted to an induction motor located below the operating platform, no stack is necessary. In this case, the vent pipe, which can be seen at the right of the front view of the boiler, rises about 8 ft above the roof of the boiler house, a 1-story building.

Among the advantages claimed to accrue from the fact that the boiler, burner, and auxiliaries are designed as a unit, factory-assembled and shipped in ready-to-operate form, is a simplification of preliminary engineering studies. A block of steam-generating capacity of guaranteed efficiency is bought. Installation is comparatively easy and possible future boiler house changes are facilitated. It is also claimed that factory-assembly permits preliminary operation and adjustment of controls, and making evaporation tests before delivery.

Exhaust Lines

The largest La Mont boiler is under construction at Deptord West Power Station of the London Power Company. This single-pass forced-circulation boiler, equipped with orifices in the tube inlets to control water distribution, will generate 350,000 lb of steam per hr at 375 lb and 780 F. Steam temperature may later be raised to 850 F.

Have you heard about the machinist who was trying to impress his girl friend by telling of the extreme accuracy required down at the shop? "Why we work to less than a thousandth of an inch," he wound up. "That doesn't mean anything to me," chirped the girl, "how many of those things are there in an inch?" This kind of floored the machinist. "I don't know," he admitted. "but there must be millions of 'em."

Charles F Kettering, Vice President (and research boss) of General Motors. has little sympathy with folks who use long words for short ideas. At the recent unveiling of the new GM diesel factory in Detroit, he put the second law of thermodynamics in its place with this homely comment. "If you are not going as fast as something else, you can't push on it. That is all the second law of thermodynamics is." Wish somebody would do that kind of a job for some of our so-called "economic laws".

From England we learn of a new magnetic oil filter to remove iron particles from recirculated lube oil. A cylindrical, high-strength permanent magnet is centered in an iron housing with a gap between. The iron particles collect on the pole of the magnet, which is removed occasionally for cleaning.

Bubbles are necessary in lots of places—champagne, soap suds, and in front of sparsely-clad dancers, to mention a few—but apparently not in condenser-water intake tunnels. Out in Omaha, an air bubble, probably caused by low water in the Missouri River, stopped the condenser water supply, caused a temporary, partial shutdown for the first time since 1924, and stopped Omaha's street car service for 32 minutes during a rush hour.

The Government power program has puzzled many people but none quite like the lady who, after a two-hour tour of one of the projects, asked her guide, the resident engineer, "What do they do with the water after they take the electricity out of it?"

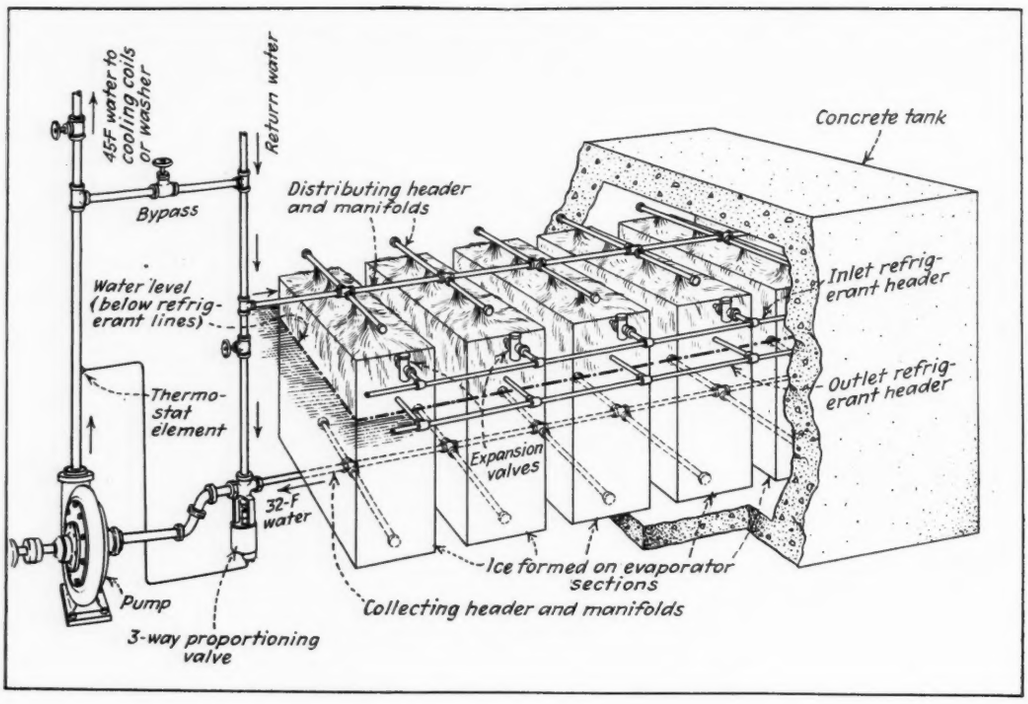


Fig. 1—Schematic arrangement of ice-storage tank and piping connections

Ice "Flywheel"

Cuts Conditioning Costs

Ice accumulator delivers 24 hours of refrigeration in 6 hours, so a 10-ton machine can do a 40-ton job

By CARL F BOESTER
Air-Conditioning Engineer, St. Louis, Mo.

AIR-CONDITIONING COSTS, in most cases, are high because operating hours are short and full-load conditions are rare. Running refrigeration equipment full-time and storing cold to be used when needed, is an obvious answer but usually has been dismissed as not commercially practical. Recent experience with installations using storage has shown it to be good practice as well as good theory, with real savings in investment and operating costs to back it up. This development opens a new line of attack, not only in air conditioning, but in the industrial field, wherever chilled fluids are circulated for process cooling.

What does such a storage system look like and how does it work? Various methods have been tried, including storage of high-pressure refrigerant liquid, of chilled water or brine, and of ice. By utilizing latent heat of fusion, ice storage gets big capacity in little space, and so seems to show most promise.

Essential feature of an ice-storage system is a series of special evaporator sections in a tank known as an accumulator. Tanks may be of steel or concrete, and are well insulated. Evaporator sections are set on close centers so that when ice is formed, it appears as if blocks of ice were suspended side by side in a tank of water. Filling and water circulation is by distributor and collector manifolds, as shown in the sketch. Water piping between the accumulator and cooling coils in the air stream is indicated schematically, as is the refrigerant piping.

Evaporator sections, operated dry instead of flooded, are served by individual expansion valves. With no ice on the evaporators, the bypass between the inlet and outlet water lines is opened and the supply line to the cooling coils is shut off, so that water is circulated in a closed path to lower the temperature rapidly. After ice has formed on the sections, the bypass is closed. Ice accumulation is controlled by immersion thermostats located between the sections, about halfway down. These are wired in series and connected to the magnetic motor-starting control so that if a single section is over supplied and a solid formation of ice results, the compressor stops.

Velocity and distribution of water in the tank are regulated by the number and size of drilled holes in the manifolds. The large ice surface over which the water flows insures a constant outlet temperature of 32 F. To secure the temperature desired for the cooling coils, usually in the neighborhood of 45 F, chilled water is blended with return water by a 3-way proportioning valve. Temperature is accurately regulated by a thermostatic element in the line to the cooling coils. Refrigeration in the form of ice meltage can be drawn from the accumulator at any rate of consumption from zero to peak capacity.

Accumulators are best made large enough so that even under worst conditions, the ice is not entirely melted off the evaporator, as the resulting rise in tank temperature and the tremendous quantity of prime surface in the evaporators would tend to overload the compressor. Multiplying the peak or design load of the air-conditioning system, by the hours of opera-

tion, and by the average percentage of maximum capacity at which the system operates gives the amount of ice to be stored. Dividing by the hours of compressor operation gives the refrigerating capacity needed. Best economy results when the compressors are run between 22 and 24 hours daily, but this figure may be cut down to allow for maintenance or to avoid operating at the time of power peak.

Design of evaporator sections is governed to some extent by the cost of power. Where it is high, increasing evaporator surface and changing the design slightly will keep consumption down. First cost is increased but not in proportion to the power savings. It is also necessary to eliminate, as far as possible by skillful design, the penalty imposed by layers of ice which build up on the sections, acting like insulation and cutting down the capacity of the refrigerating equipment. To offset this penalty, the efficiency of refrigeration for storage is higher because of constant operation at practically full load.

To keep down the size of storage units, evaporator sections must displace a minimum quantity of water. In units I have designed, this displacement is about 1.5 cu ft. Making allowance of 37 cu ft for a ton of ice, for circulation space, and for the tank itself, approximately 50 cu ft (a cube roughly 3 x 4 x 4 ft) is required to store a ton of ice. Although storage installations occupy more total space than conventional equipment, the storage tank can be made in almost any dimensions so that space not suitable for other use can be employed.

So much for the construction and operation of a storage system. How does it save in investment and operating costs and what other advantages does it offer? The following comparison, based on figures from an actual installation with a maximum cooling load of 40 tons, will show the saving possible in first cost. The system operates for six hours daily at about 65% of capacity. This percentage will apply to most commercial enterprises operating eight hours, or less, daily. It will be even lower for theatres or other installations running twelve hours daily.

Cost Comparison

Under the conditions given, 6.5 tons of ice must be accumulated every 24 hours; a 10 ton compressor will handle the job nicely. A complete 10-ton unit costs $550, a 10-ton evaporator condenser $500, a 40-ton cooling unit $850, and a chilled water pump $90. The storage equipment, complete and erected (10 tons capacity) would add $1500 to the cost and $450 for setting and connecting the apparatus would bring the total to $3940.

If a conventional direct-expansion system were used, two 15-ton and one 10-ton compressors would cost $1650. A 40-ton evaporator condenser would add $1800, and the expansion coils would be $1325. Control for the operation of the three compressors would cost $100, additional Freon at $50 would be required, and labor for piping and erection would make the total bill $5375. Since the air-distribution system would be the same in any case, there is a clear saving of $1400 in favor of storage.

Where power is purchased, operating savings will be greatest on rates with heavy demand charges, and it may be possible to get rates for off-peak operation similar to those given ice companies. Where power is privately generated, and 24-hour service is available, the same lowering of cost should result from improved load factor. Better load factor and the vastly decreased capacity needed should also encourage the installation of diesel- or gas-engines to drive compressors, where these fuels are cheap. In all cases, lower investment costs mean lower fixed charges.

Savings are greatest when hours of operation are short, especially in extreme cases such as churches, legitimate theatres, meeting rooms, and ball rooms, but as operating hours increase, the percentage of capacity used tends to decrease, so that storage still retains an advantage. Whether it pays in any given case is a matter for individual analysis.

Where condensing water is evaporatively cooled, compressor efficiency improves because of night-long operation when wet-bulb depression is greatest. Other advantages of storage are increased reliability—block ice can be used if the compressor fails—and increased safety due to the minimum refrigerant piping necessary.

There is nothing really new about refrigeration storage; the job has been to make it practical, to show that properly applied it can effect savings in both investment and operating costs. And there seems to be no reason why the same idea can't be made to show savings in industrial applications where water is chilled for circulation to process departments.

Fig. 2—Storage tank serving an air-conditioning system with a maximum cooling load of 100 tons; operated four evenings a week

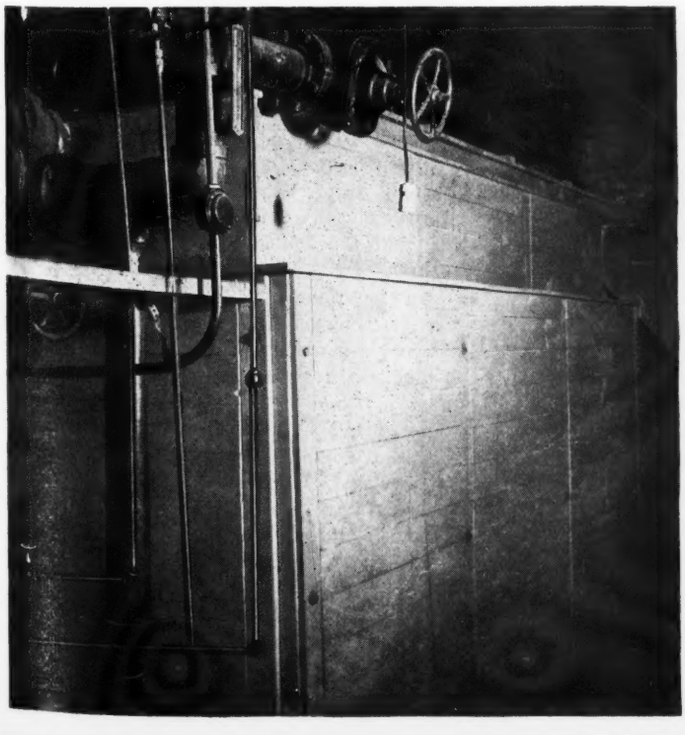
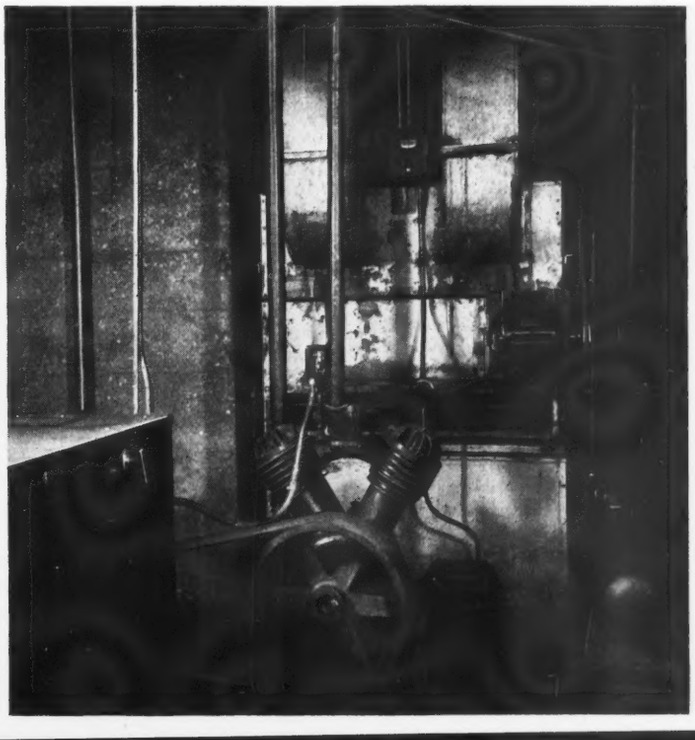


Fig. 3—This 15-ton compressor, driven by a gas engine, supplies refrigeration for the storage tank shown in Fig. 2. Evaporative condenser in the foreground



Wrong, by Chimney!

A Comedy of Errors

By E J TANGERMAN
Consulting Editor

(and divers other crack reporters)

SAID WE in January *Power,* "Four years ago, cavalrymen at Fort Oglethorpe, Ga., began to do their riding at a safe distance from the 125-ft brick power-plant stack, for a crack had appeared at its top and had worked down about 40 ft, something over 25 ft of it being opened out to a maximum of about 3 in. at the top. Engineer J F Masefield had asked for an appropriation to get the stack repaired . . . a brother engineer down in Florida . . . suggested he plant some slips of Florida vine at the base of the chimney. It sounded ridiculous, but Masefield carried three shoots back with him and tried them. One died, but the other two grew to the top of the stack within a year, encircled the crown, and actually began to pull the crack shut. Now, four years later, the vine is over 3 in. in diameter and the crack is closed, except for the little bit visible at the top of the stack . . ."

Stack Rears Its Ugly Head

Last December, the head of our Illustration Department, back from a swing through the South with his assistant, told me that story. I called him a condemned fabricator—at which crack he handed me this photograph and another showing the whole stack.

They looked pretty convincing, and he had notes and data to supplement them, which he'd gotten from the engineer and had checked by the Major commanding the Post. So we published it.

Came the dawn. Our crack story was seen by Julian LaRose Harris, executive editor of *The Chattanooga Times.* Chattanooga is only 7.5 (about) miles from Fort Oglethorpe, and wrote Editor Harris to me, "As I have been here in Chattanooga two and a half years, I did not see how this phenomenal vine could have roared to the top of the smokestack (Please, Mr. Harris, only locomotives have those!) in Fort Oglethorpe and failed to attract the attention of our local staff. Second, I though this smoke stack was not nearly as high as you said it was. Third, I thought it incredible that a crack in masonry could be pulled together by a vine, although it is conceivable that this vine might have prevented further cracking and kept the chimney in good standing, so to speak."

So, being a good editor as well as a smart one, Mr. Harris sent out a reporter to check. The result was a two-column feature article in the *Times* for Feb 6. Reported he, "The story is entirely true except for the following details: One—the crack did not appear four years ago. It appeared quite a few years ago. Two—The crack did not start at the top of the stack, but some distance down. Three—the stack is not 125 feet high. It is seventy-five feet high. Four—The crack is not forty feet long. It is about eighteen feet long, running in a zig-zag line. Five—The vine was not planted four years ago. It was planted thirteen years ago, when the slips were brought from Florida by Mrs. Hugo Everett . . . Six—The vine did not grow to the top of the stack in one year. It took the vine eight years to reach the top. Seven—The vine has not closed the crack at any place in the stack, according to E Cooper, who is in charge of the pumping station."

Credulous World

Then, to me, Mr. Harris wrote: "For your amusement I enclose you a clipping which shows, I think, that out of a half-dozen or more statements made, not more than two were accurate. I wonder how many newspapers reproduced this item from *Power* without investigating it? I also wonder how a magazine, which is presumed (Why, Mr. Harris!) to be accurate, could send out to a credulous world an unchecked item of this type?"

"Pictures don't lie", so they taught me;
I always believed what they said—
But this photo lied and it caught me.
Oh boy, is my manly face RED!

To which I replied, Feb. 10, "You would take advantage of a poor technical editor and send out a "crack" reporter to cover our famous Fort Oglethorpe crack story! . . . I think it was Confucius who said once that 'a picture is worth ten thousand words'—so here's your picture. You will note that it does show a crack at the top, which apparently your crack reporter missed . . . I confess I never saw the stack, and I'm not a good guesser of heights on pictures. . . . It seemed a little far-fetched to doubt the word of two observers, substantiated by photographs and notes from the man who had planted the vines and corroborated by his superior. . . . Now you've disillusioned me and my heart is sore. We won't argue about stack height and crack length—neither is important, although they do help to bulk your feature story. Nor will I challenge the growing time of the vine—75 feet in a year seems like a lot, even in a Georgia summer. But you might get your crack reporter to one side and ask him one or two further questions. He got his facts from E Cooper, present engineer, who didn't plant the vines, and is apparently a new man. We got ours from the man who planted them — and should know. Did your man check with anyone in authority—

or was the story too good to bear checking, in case some of the facts might break down a little? . . . Honestly, I'm not casting aspersions on your crack reporter, but to satisfy my own curiosity, I'd really like to know. . . . Besides, *Power* has a reputation for veracity that we'd like to keep. If we had our facts wrong, we want our readers to know about it —if for nothing else than to keep many other cracked brick stacks from growing a beard of Florida vines . . ."

That letter irked Editor Harris into a "second hegira" "trip", in English) to Fort Oglethorpe for his ace reporter, a cameraman, and Robert Sparks Walker, "famed naturalist . . . Mr. Walker contributes to the New York Herald Tribune, the Christian Science Monitor, The Chattanooga Times, and a number of nature magazines and is a botanist of no mean standing." This is where our face begins to redden—they found out some more things which were duly reported in *The Times* for Feb 24.

Mr. Walker says our Florida vine is simply *parthenocissus quinquefolia,* Virginia creeper to you. It grows wild from Massachusetts to Florida and points west. Said Mr. Walker, "The vine holds onto the stack by fragile tendrils and it would be absolutely impossible for it to pull a crack shut. The crack in the stack might be pulled shut by a supple-jack vine, which I have seen choke a pine tree to death in its python-like grasp."

To Bury Caesar

O.K. Mr. Walker should know. As far as I can tell some vines grow grapes and some poison ivy. All I know is that as a kid I saw tree roots and twisting vines crush brick sewers and even tile—and as a high-school boy learned that if you put a band around something tight, then thicken the diameter of that band an inch, the circumference of the included circle is decreased a little over three inches—and something has just got to give. Tendrils have nothing to do with it; it's the tightening of the coil due to natural enlargement of diameter of the vine. Even out in this disbelieving East, there have been several cases in which wisteria vines choked oak trees. But we came here to bury Caesar, not to praise him. I'm wrong, and that's that.

But that ain't all. The caravan rechecked the stack height—it's 80 ft, not *Power's* 125 (Mr. Masefield's guess for the photographer) or *The Times* 75 ft. *Power's* 40-ft crack, (with 25 ft open), which *The Times* first called an 18-footer, is either "8 to 10 ft" (*Times* 2nd article) or "10 feet" (Mr. Harris' 2nd letter). But Editor Harris admits, "Your statement that the crack started at the top was controverted in *The Times'* first article . . . the crack did start at the top and can be plainly seen." Score one for *Power.*

Power said the vine was planted four years ago; *The Times* first called it 13. Now says Editor Harris, "It was, however, planted nine years ago. To be exact, we have the statement of Mr. Mansfield that it was planted May 18, 1928, at 1:15 P.M. He gave this statement to us from a log-book which he has kept for a number of years." (Proving that a log has undying usefulness, even when it flattens me).

Our photographer called the engineer J F Masefield—his name is Joseph E Mansfield (by *Times* affidavit). *Power* credited the slips of vine to Mr. Mansfield *The Times* first said Mrs. Hugo Everett brought them. Her last name is actually Evers.

Sauce for the Goose

Power further said the vine was planted to pull the crack shut. But says Editor Harris, ". . . The slips of vine were planted merely to take some of the nudism from the bare bricks of the 80-foot stack and perhaps hide the crack which started this battle for facts . . . It grew to the top of the stack in five years, two months . . ." There's one on Mr. Harris, because Mr. Mansfield's statement, as reported by *The Times,* is: "Mrs. Evers was visiting in Ortega, Fla., in May of 1928, and when she returned she brought with her a number of slips of plants . . . two years later it (the vine) had grown to a height of about eighteen or twenty feet, when one fatigue day soldiers who were cleaning up around the post cut it down by mistake. The vine then went up the stack in two branches and reached the top about four years ago." May, 1928, was 9¾ years before February, 1938. Subtract the first two years of fruitless growing and the four years since the vine reached the stack top, and you get 3¾ years—not five years and two months, or even eight years, as first stated in *The Times.*

Says Mr. Harris also: "You state in the article in *Power* that the crack appeared four years ago, whereas the crack appeared about nine years ago . . . " But the second *Times* feature story said, "Mr. Mansfield said he had been at Fort Oglethorpe since the post was built, and the stack was put up in 1910, but he didn't know just when the crack appeared." Whence the nine years, Mr. Harris?

Further insists *The Times,* ". . . The *Power* staff man who turned in the story did not talk to him" (Mr. Mansfield). *Power* has an affidavit that the photographer did call—with pictures as further proof. Besides, he is *not a staff member.* That's two more on Mr. Harris.

The Times' first article said the slips were "presented to Joe Mansfield", the second says, "Sergt Evers planted the vine at the base of the smokestack . . ." Which is right?

We could go on like that for hours. But let's end with these quotations from Mr. Harris' concluding paragraphs, "May I now add one thought in connection with this entertaining battle between truth and error? "Facts crushed to earth will rise again, but not more than 80 feet." I . . . hope . . . since Fort Oglethorpe is somewhat under the aegis of Chattanooga, and *The Chattanooga Times* is the very palladium of precision, that you will make in *Power* an adequate statement concerning your errata. That statement will serve as a warning to the world at large that where error impinges on our area *The Chattanooga Times'* motto is *noli mi tangere;* or *Tangerman* if you wish to bring the old slogan up to date."

At that point Mr. Harris should start a "hegira" of naturalists to Australia to study a weapon called the boomerang, which occasionally returns to bang the very Devil out of its thrower. Or to quote an old American (I hope) proverb, "The pot can't call the kettle black." For his Latin slogan (which means "Touch me not") should be spelled *noli me tangere.* Said *The Times,* "The score at the end of the second inning stands: *Power* nine errors, *The Chattanooga Times,* five errors." But add the six additional errors above (in a "correction" story, too!) to the account of the "palladium of precision" and the score becomes: *Power* nine errors, *The Chattanooga Times* eleven errors (thus far counted) after the first half of the third inning.

The Durn Things Lie!

Thus closeth (we hope) the Comedy of Errors, or The Case of the Crack Reporter Who Cracked down on a Crack Story. We admit we're wrong —don't plant Virginia creeper to close a stack crack; try supple-jack or wisteria. And don't even believe a photograph—the durn things lie!

Seriously, we're worried about the two *Power* readers who wrote Mr. Mansfield for details, and about Mr. Harris and his paper's impunging of our general accuracy. Mr. Harris, when you say that, SMILE! Unless the printer tricks us, we have told all—in this as in previous cases.

After a little sober thinking, maybe the title of this whole business should be "Much Ado About Nothing."

Tailored Joints—II

March Power *described three methods of cutting pipe for field welding of joints. This chart shows curves for cutting tees*

By E W P SMITH
Consulting Engineer, Lincoln Electric Co

FOR tee connections where the through run is of larger size than the branch pipe, this additional chart, Fig. 7, gives the necessary dimensions for laying out curves to be cut in both sections of pipe. As previously described, the cutting curve may be determined by a fixture, or templates may be formed from the chart, or the cutting curve may be inscribed on the pipe itself.

A circumference is first scribed or chalked near the end of the branch pipe and divided into 16 equal parts by doubling a string four times. Then four dimensions are found from the chart, as indicated in the example, and laid off at right angles to the scribed circumference. The sketch indicates how this is done. Since the four quarters are symmetrical, the same four dimensions are laid off in proper order until a curve is marked all around the pipe.

For the through run, a centerline is marked through the point of connection and parallel to the axis of the pipe. This line is divided into eight equal parts (totalling a length equal to the diameter of the branch pipe) and lines drawn at right angles as indicated in the lower sketch. The four dimensions found from the lower half of the chart are laid out on both sides of this line and repeated to form the other symmetrical half. The dimensions given are for the actual line of intersection so that allowance must be made for scarfing as previously described.

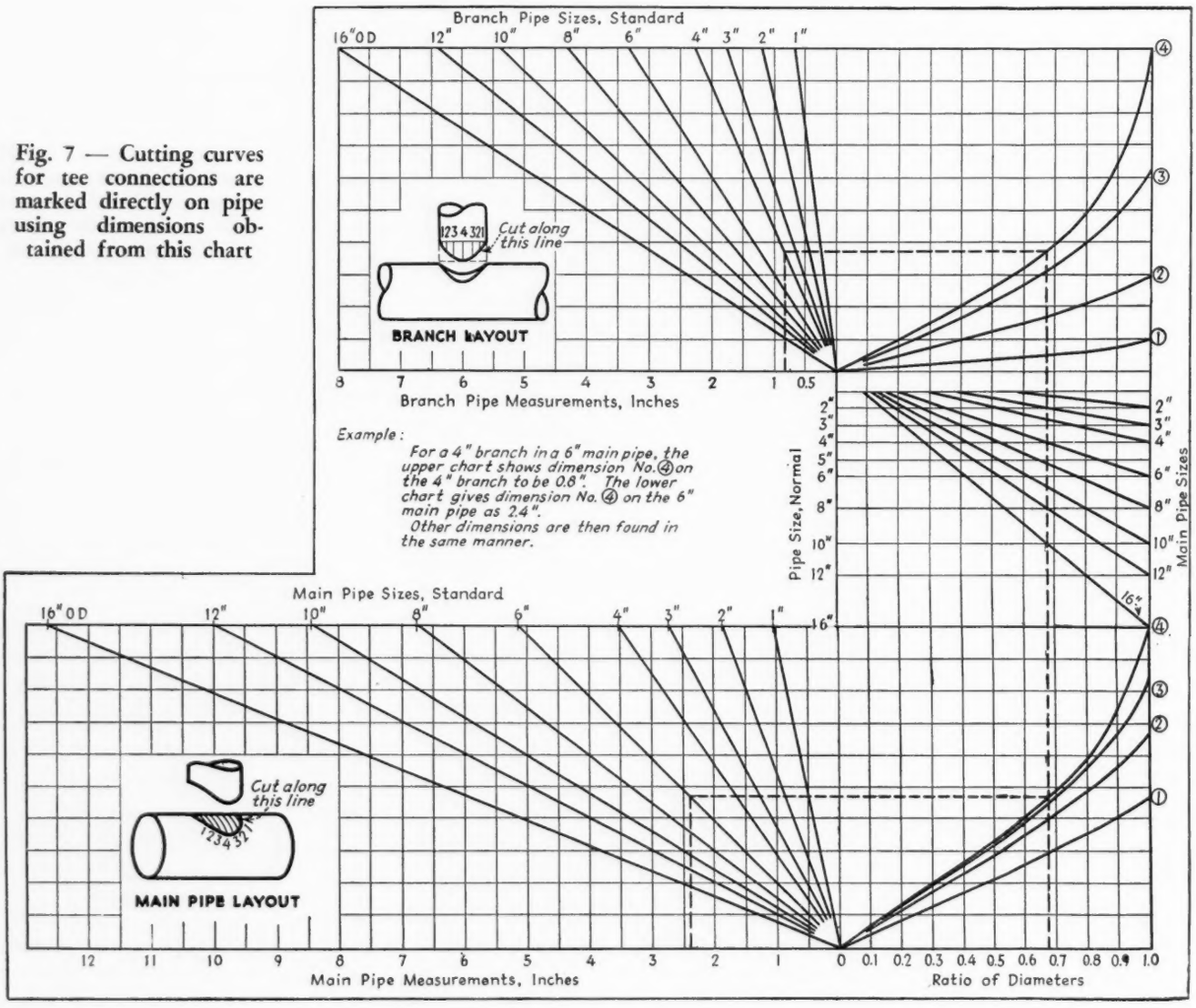


Fig. 7 — Cutting curves for tee connections are marked directly on pipe using dimensions obtained from this chart

ELECTRICITY *on the* JOB

TODAY'S knowledge of electricity was hard won through the ages by countless pioneers—curious-minded men who wouldn't take things for granted. Let's look at the record:

585 BC—MILITUS tells of amber ("elektron") which attracts chaff when rubbed. Aristotle writes of loadstone "with a soul to move iron".

400 BC—EURIPIDES names lodestones "magnets", because the best ones come from the city of Magnesia.

1663—VON GUERICKE builds a static generator.

1752—BEN FRANKLIN draws sparks from a kite string.

1785—GALVANI makes his frogs-legs experiment, leading eventually to Volta's copper-zinc-acid battery.

1820—AMPERE discovers attraction and repulsion of parallel circuits.

1827—OHM discovers Ohm's law.

1831—FARADAY invents the "dynamo".

1881—EDISON builds a "jumbo" generator, weighing 27 tons.

1882—First "central stations" start operation in London, Appleton (Wis.) and New York.

But why go on? It is clear enough that electricity was but a plaything of science until about 1830, that it was swinging toward the practical during the next half century and that around 1880, under the lash of Edison and many others, it began changing the face of the earth. The record shows an idea incubating for 25 centuries and rebuilding the world in the next sixty years.

Development since Edison has been so amazing that the man in the street long since used up all his adjectives trying to describe it. Today he has definitely graduated from the wonder stage—he takes electricity for granted. In 1938 he no longer asks "what is electricity?" but rather "how can I use electricity to do a job?"

This question has been asked and answered thousands of times for specific problems, and the whole broad story of electricity has been told hundreds of times in heavy volumes. Technical articles keep the engineering reader in touch with new developments. Yet, in spite of all this wealth of available information, the engineer still has an unfilled electrical need—a summary of basic electrical facts so concise that it can be read in a couple of hours, yet complete enough and practical enough to help solve such everyday problems as motor selection, wiring and protection.

To fill this gap, *Power* here presents its 18th special-subject section, devoted solely to "Electricity on the Job", to the *applications* of electricity after it leaves the switchboard.

This treatise was made to be read and used by practical engineers, men who have "worked around electricity" for years. For them the articles on Fundamentals will quickly bring back to mind, where necessary, the basic facts. The section then turns directly to practical matters, and hewes strictly to that line throughout the remaining articles: Conductors, Power circuits (with tables), Motors, Motor control, Power-factor correction (with charts), Motor protection.

All readers, even those who are electrical experts, need frequent reminders of the real essentials. Here they are in twenty pages—easy to find and use when a decision must be made or a job done.

FUNDAMENTALS

IN TELLING the story of electricity, just as in building a house, foundations come first. And further, these foundations or fundamentals must be simple, sound and straightforward. Then we have an understanding of electricity on which to erect a knowledge of how it behaves and of the equipment that makes and uses it.

There are two types of magnets: permanent and electro. They both have the same properties and act the same under identical conditions. Any magnet is surrounded by a field of force represented by the lines, Fig. 1, emanating at the *N* pole and going to the *S* pole. This field acts as though each part of it repelled every other part, tending to fly out in every direction.

Magnetic Repulsion

If like poles of two magnets are brought near each other, Fig. 2, they repel, just like two fans blowing against each other. Unlike poles attract, the field of one joining that of the other and surrounding the two magnets, Fig. 3. Here, the field between the two magnets, like rubber bands in tension, pulls them together.

An electric current flowing through a conductor produces a magnetic field that forms concentric circles about it, Figs. 4 and 5. Looking along the conductor in the direction of current flow, the magnetic field rotates clockwise, Fig. 4, and counterclockwise for reverse flow, Fig. 5. If two conductors, in which current is flowing in opposite directions, are brought near each other, Fig. 6, fields between them repel and tend to force the wires apart.

Current flowing in the same direction in two parallel conductors sets up opposing magnetic fields between the conductors, and the fields combine to surround the two conductors, Fig. 7, forcing them together. In Fig. 7 we have the principle of the electromagnet shown in Fig. 8, a cross-section of a coil having 4 turns. The field of each conductor combines with that of the others to create *N* pole at one end of the group and *S* pole at the other.

If a conductor is placed in a magnetic field, as in Fig. 9, and moved to cut across the field, a voltage will be generated in the wire. This is the simple principle of an electric generator. To determine direction of voltage, place thumb and first two fingers of the right hand at right angles to each other, Fig. 10. With the forefinger pointing in the direction of lines of force, and the thumb to direction in which conductor moves, the middle finger indicates direction of voltage.

If a conductor carrying an electric current is placed in a magnetic field, Fig. 11, it tends to move at a right angle to the direction of the field, which is the principle of an electric motor. To determine the direction of the force on the conductor, place thumb and first two fingers of the left hand at right angles to each other, Fig. 12. When the forefinger points to direction of magnet field and middle finger to direction of current, the thumb shows direction of force on the conductor.

Fig. 13 is a diagram of a simple dc generator with a ring armature rotating in direction of the curved arrow. As the conductors move through the magnetic field, voltage generated will flow in the conductors in a direction indicated by the arrow heads, as can be determined by the right-hand rule, Fig. 10. Voltage direction in top and bottom halves of the winding is toward the right-hand brush to make it +, where current is taken out of the armature. Current reenters armature at the — brush.

A dc motor is similar to a dc generator, but current is supplied to its armature winding to produce turning effort, Fig. 14. When current flows in the winding as indicated by the arrow heads, the armature will rotate in the direction of the curved arrow.

The machines in Figs. 13 and 14, are known as non-interpole generators. On most modern dc machines, small poles are placed between the main poles, Fig. 15, to improve commutation. These poles are known as interpole or commutating poles and their windings are connected in series with the armature.

Ac generators may be single-phase, 2-phase or 3-phase, but are generally 3-phase. A single-phase machine can

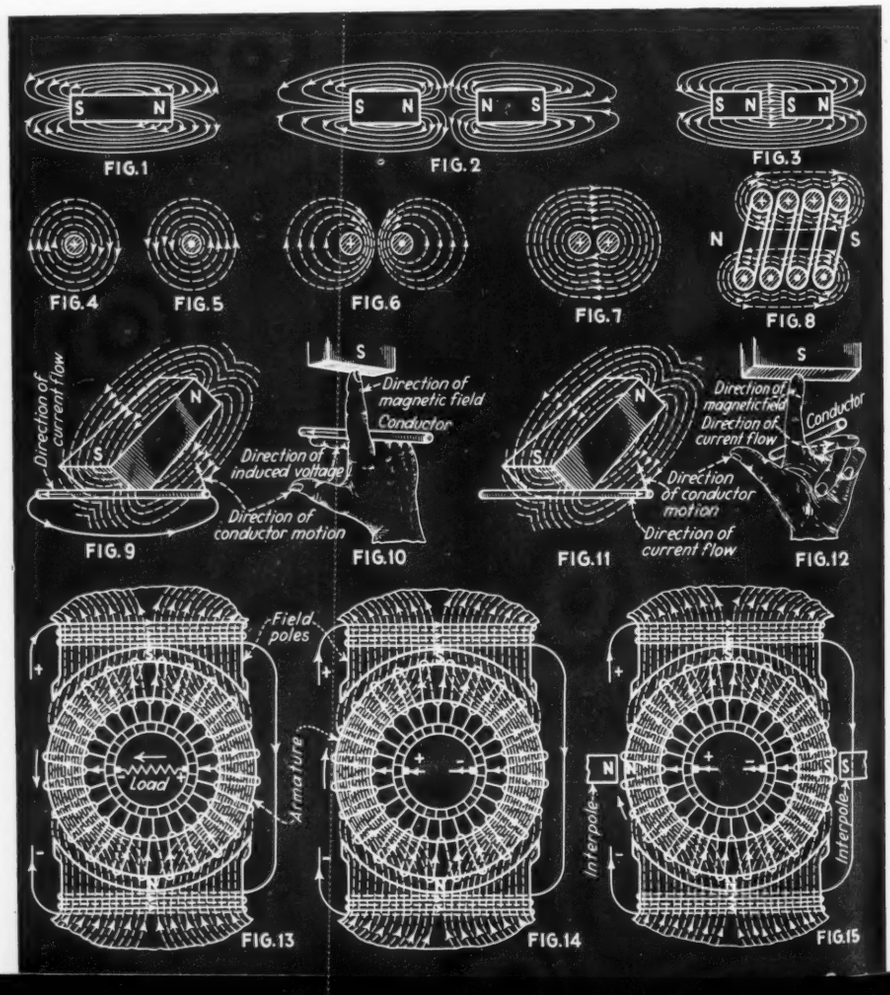


Fig. 1—Permanent magnet and field. Fig. 2—Like magnetic poles repel. Fig. 3—Unlike magnetic poles attract. Fig. 4—Magnetic field around a conductor, current flow away from reader. Fig. 5—Magnetic field around a conductor, current flow toward reader. Fig. 6—Opposite directions of current flow causes conductors to be repelled. Fig. 7—Same direction of current flow in two conductors causes them to be attracted. Fig. 8—Magnetic field of a 4-turn electromagnet. Fig. 9—Fundamental principle of an electric generator. Fig. 10—Right-hand rule for direction of generated voltage. Fig. 11—Fundamental principle of an electric motor. Fig. 12—Left-hand rule for direction of motor rotation. Fig. 13—Diagram of a dc generator. Fig. 14—Diagram of a dc motor. Fig. 15—Interpole dc machine

be somewhat similar to the generator in Fig. 13, but has its armature winding connected to two slip rings, Fig. 16. With the armature in the position shown, voltage in the two top quarters of the winding opposes that in the two lower quarters. Consequently, voltage at the brushes is zero.

When the armature has turned 90 deg to position, Fig. 17, top and bottom halves of the windings are connected between brushes. Voltages in all conductors in each circuit are in the same direction, therefore add to give a maximum value. Another quarter revolution brings voltage back to zero and still another quarter turn will give maximum again, but in the opposite direction to the first. Thus, as the armature rotates, its voltage goes through a series of values starting at zero, Fig. 19, gradually increasing to maximum, then decreasing to zero and reversing and going through the same series of values in the opposite direction.

A voltage or current wave, surging first in one direction and then in the other, Fig. 19, is called one cycle. The rate at which the voltage and current alternates back and forth in a circuit is termed its frequency, expressed in cycles per second. Frequency equals the speed in rpm at which the alternator operates times its number of poles divided by 120. Thus, an 1800 rpm, 4-pole alternator will generate at a frequency of $(1800 \times 4) \div 120 = 60$ cycles per sec.

A 2-phase machine can be like a single-phase, except that it has 4 rings. Fig. 18. It generates two voltages similar to that of the single-phase machine, but one occurring 90 deg later than the other, Fig. 20. That is, when one voltage is maximum, the other is zero.

In a 3-phase machine of the simplest form, three slip rings tap 120 deg apart into a ring winding, Fig. 21. Voltages available between the rings have the relation of Fig. 22. Only three leads are taken from the generator and load is connected to each pair of leads, *A-B*, *A-C* and *B-C*. Commercial designs of ac generators usually have a stationary armature, known as the stator, and a revolving field structure called the rotor.

So far, we have covered general fundamentals of dc and ac circuits. Now the relation between voltage, resistance, current and power in these circuits will be considered. In a dc circuit, current I in amperes equals volts E divided by resistance R in ohms (Ohm's Law). This may be expressed as $I = \frac{E}{R}$ Thus, if 120 volts are applied to a circuit of 10 ohms resistance, the current $I = 120 \div 10 = 12$ amperes. Resistance R equals volts E divided by current I in amperes. When a current of 15 amperes flows in a 120-volt circuit, resistance $R = \frac{I}{E} = \frac{120}{15} = 8$ ohms.

Volts E equals current I in amperes times resistance R in ohms. A current of 20 amperes will flow through a resistance of 12 ohms when volts $E = IR = 20 \times 12 = 240$.

Rate at which power is transmitted in a circuit is expressed in watts, and equals the product of volts and amperes, that is watts $W = EI$ and kilowatts $Kw = EI \div 1000$. If the voltmeter in a circuit reads 240 and the ammeter 150, then kilowatts $Kw = 240 \times 150 \div 1000 = 36$. A kilowatt-hour is the average rate at which power is transmitted for an hour. Thus, if power is transmitted at an average rate of 36 kw for 2.5 hr, $kwhr = 36 \times 2.5 = 90$.

Electrical horsepower equals $W \div 746$. If a 15-hp, 230-volt motor takes a full load current of 56 amperes, the power input to the motor at full load in electrical horsepower $= 230 \times 56 \div 746 = 17.27$ hp.

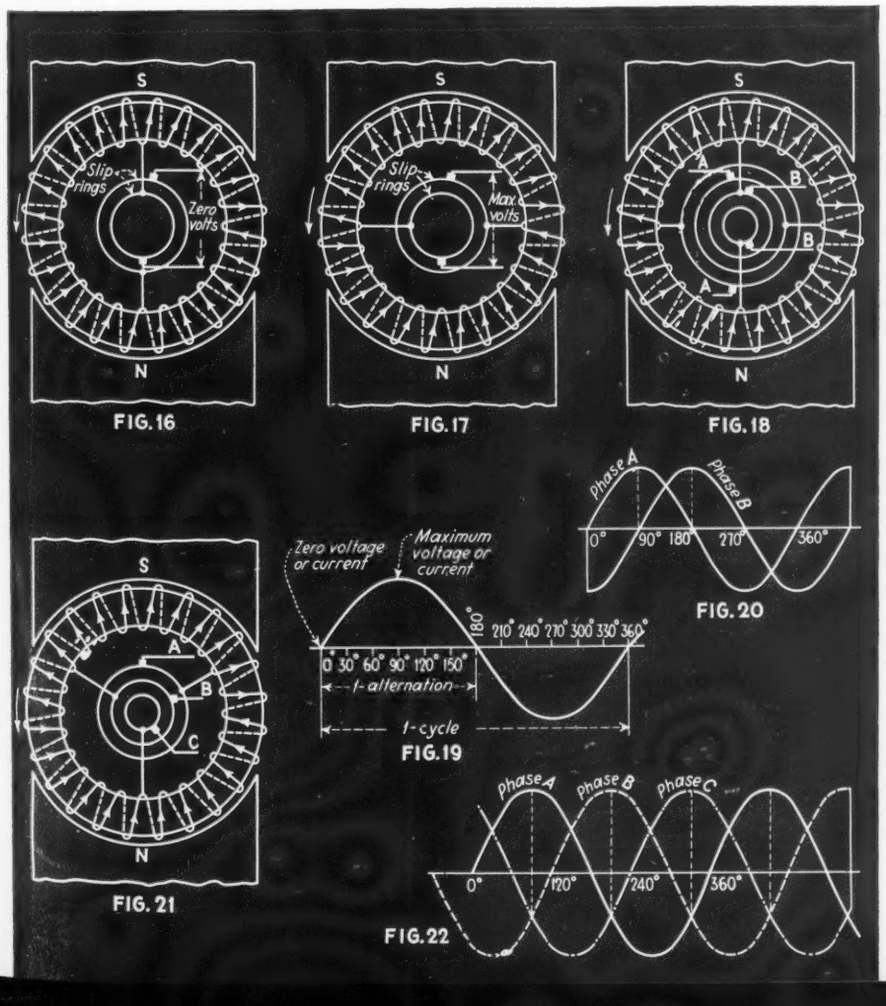
AC Calculations

Multiplying an ammeter reading by the voltmeter reading in an ac circuit will not generally give watts transmitted to the load, but a higher value known as volt-amperes (apparent power). A wattmeter is so constructed that it will indicate only power taken by the load. We therefore say that the wattmeter reading (watts) is true power. The ratio of true power (watts or kilowatts) to apparent power (volt-ampere or kilovolt-amperes) gives a value known as power factor, usually expressed as power factor $Pf = W \div VA$ or $Kw \div Kva$.

Assume a voltmeter reading of 440, an ammeter reading of 50 and a wattmeter reading of 17 kw. Kilovolt-amperes, $Kva = EI \div 1000 = 440 \times 50 \div 1000 = 22$. The power factor $Pf = Kw \div Kva = 17 \div 22 = 0.77$. This expression may be transposed to read kilowatts, $Kw = Kva \times Pf$ and kilovolt-amperes $Kva = Kw \div Pf$.

In a balanced 2-phase circuit, that is, one in which volts and current in each phase are equal, kilovolt-amperes $Kva = 2\,EI \div 1000$. If volts across each phase are 2300, the current 35 amperes and the wattmeter indicates 145 kw, then $Kva = 2 \times 2300 \times 35 \div 1000 = 161$ and power factor $Pf = Kw \div Kva = 145 \div 161 = 0.90$.

Phases of a 3-phase generator are so interconnected that for a balanced load, kilovolt-amperes, $Kva = 1.372\,EI \div 1000$. When the voltmeter reads 440 and the ammeter 250 on a 3-phase circuit, kilovolt-amperes, $Kva = 1.732 \times 440 \times 250 \div 1000 = 190.5$. If the wattmeter reading is 175 kw, then power factor, $Pf = Kw \div Kva = 175 \div 190.5 = 0.92$.



Figs. 16 and 17—Diagram of a single-phase alternator. Fig. 18—Diagram of a two-phase alternator. Fig. 19—Single-phase voltage or current wave. Fig. 20—2-phase voltage or current waves. Fig. 21—Diagram of 3-phase alternator. Fig. 22—3-phase voltage or current waves

CONDUCTORS

TYPES OF ELECTRIC wire and cable construction, insulation and protective covering, duct designs, conduit fittings, cable terminals, connectors and other devices for power circuits are legion. In general, insulated power conductors are made of copper. Aluminum wires are permitted by the National Board of Fire Underwriters, but their current-carrying capacity is taken as 84% of that of copper. For bare conductors as in busbars and overhead high-voltage transmission lines, aluminum is used extensively as well as copper. Where it is desirable to combine strength of steel with conductivity of copper, copper-clad steel wire is used.

Conductor Sizes

Several wire gages have been developed, but copper conductor sizes are usually expressed in American Wire gage or Brown & Sharpe (AWG or B & S) gage sizes or in circular-mil cross sectional area, as in the wire tabe, page 220. The American Wire gage is the same as the Brown & Sharpe and runs from No. 40, 3.145 mils in diameter, to No. 0000, 460 mils diameter for solid wires. Conductor sizes larger than wire gage numbers are expressed in circular-mil cross-sectional area and, for round cross sections, run from 225,000 to 5,000,000 circular mils.

A mil is 0.001 in. (one thousandth of an inch) and a circular mil the area of a circle one mil (0.001 in.) in diameter. Squaring the diameter in mils of a solid round wire gives its area in circular mils. For example, a No. 10 wire is 101.9 mils in diameter and has a circular-mil area of $101.9 \times 101.9 = 10{,}380$.

Power conductors are made in a wide variety of forms, such as round-solid, Fig. 1, and round-wire stranded, Fig. 2. These two are most widely used for power-distribution circuits. The National Electrical Code requires that all conductors larger than No. 7 installed in conduit or ducts be stranded, except when used as busbars.

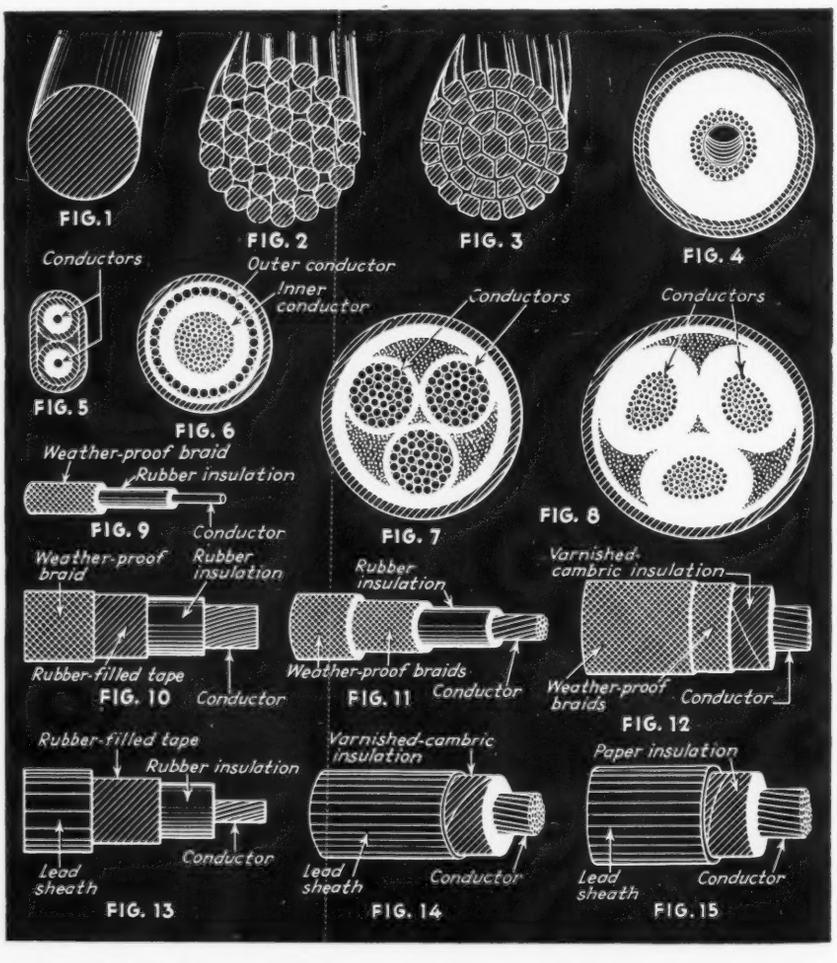
Round-wire stranded conductors require more space than do solid ones. To reduce size for a given circular-mil cross section and retain flexibility of stranding, the construction in Fig. 3 is used for large cables. For very high voltage, hollow-conductors filled with oil, Fig. 4, and others are used.

Many types of multiple-conductor constructions are available, the simplest of which is two insulated wires under a common sheath, Fig. 5, for the smaller sizes of conductors. To get twin round conductors in a minimum of space, a concentric arrangement, Fig. 6, has come into use. Where three conductors are cabled under one cover, round strands may be used, as in Fig. 7, or the more compact-strand design, Fig. 8.

Except for high-voltage overhead transmission lines and busbars, most power conductors have insulation over which is a protective covering. The insulation may be rubber compound, varnished cambric, paper, asbestos or special compounds equivalent or superior to rubber. Minimum standards of insulation have been established by the National Board of Fire Underwriters, and wire conforming to these standards is called "code wire."

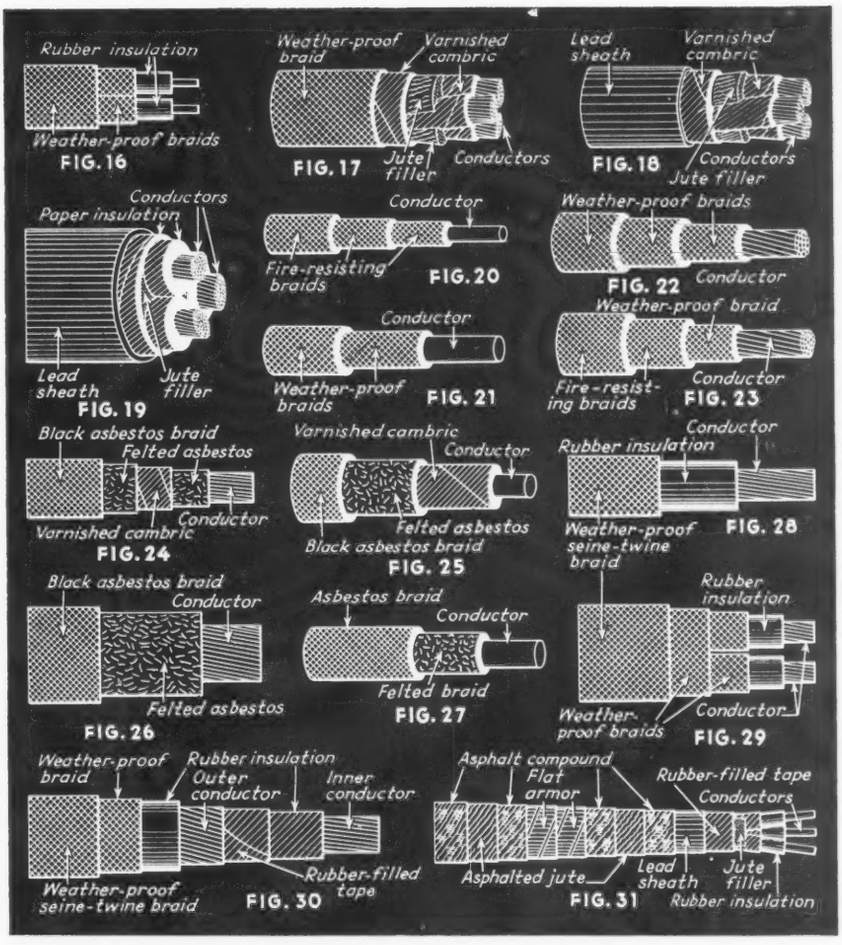
All wire, whether insulated with rubber, varnished cambric or paper must have an outside protective covering. For ordinary power wire, this is usually cotton braid applied directly over the rubber, Fig. 9. For larger wire a rubberized tape is first applied over the insulation, Fig. 10. Double braid, Fig. 11, is required by the Code on all wire larger than No. 7. When braid has been applied, it is then impregnated with a weatherproof compound over which is applied a weatherproof or a flameproof compound, depending on the type of finish required or the outer surface.

Vanished-cambric-insulated cables may be given a cotton-braid outer cover, Fig. 12. For damp and wet places, underground ducts and other locations where superior protection is required for the insulation, a lead sheath is placed around the cable. On rubber-insulated conductors, a rubber-filled tape is put over the rubber before applying the lead sheath, Fig. 13. When the conductor is varnished-cambric insulated, lead sheath is applied directly to the insulation, Fig. 14. Paper-insulated conductors always require a lead sheath, Fig. 15.



Figs. 1 to 4—Cross sections of single conductors. Figs. 5 to 8—Cross sections of multiple-conductor cables. Figs. 9 to 15—Types of insulated conductors

Figs. 16 to 31—Types of insulated single- and multiple-conductor wire and cable



Duplex conductors (two separate conductors under one sheath flat), Fig. 16, are insulated very much as single rubber-insulated conductors. A braid is placed over the rubber and the two conductors covered with another braid treated and finished with weatherproof or fire-resisting compound. When three or more insulated conductors are grouped, a treated jute filler is applied to form a true circle. On a varnished-cambric-insulated cable, a layer of varnished cambric is applied over the jute filler, followed by a protective covering of cotton braid, Fig. 17, or a lead sheath, Fig. 18. The same general construction applies to medium-voltage paper-insulated cables, Fig. 19.

Where temperature exceeds the limits allowed for rubber- or varnished-cambric-insulated wire but is not more than 194 F, a slow-burning insulation, Fig. 20, may be used in permanently dry places. This insulation comprises three braids impregnated with a fire-resisting compound. For out-of-doors service, weatherproof-insulated wire can be used, covered with two or three braids impregnated with weatherproof compound, Figs. 21 and 22. Such conductors are not approved for interior wiring, because their insulation, if moist, becomes a fairly good conductor. Under certain conditions, slow-burning weatherproof conductors are permitted. These have two outer braids impregnated with a fire-resisting compound and an inner braid filled with weatherproof compound, Fig. 23.

Asbestos Insulation

Asbestos, also, is used as an insulation where high temperature and dryness exist. Where flexibility is required, a cover of pure long-fiber asbestos impregnated with a flame-resisting and moistureproof compound is first applied to the conductor. Over this is applied varnished-cambric tape, Fig. 24, with a thin layer of plastic, nonhardening insulating compound between the tapings to eliminate air space and make the cable moistureproof. The varnished cambric also gives the insulation flexibility. The next covering is a second layer of asbestos treated in the same way as the first layer. The outer covering is a closely woven asbestos completely saturated with a black insulating compound. This resists moisture, flame, and acid. Oil of a quality generally used in switches and in lubrication of generators or motors does not injure cables insulated with varnished cambric and asbestos. They can therefore be run directly to oil switches and oil-filled transformers, or used as generator leads.

An asbestos, varnished-cambric-insulated switchboard and rheostat wire is insulated as is, the station and apparatus cable just described, except that the inner asbestos layer is omitted and the varnished cambric is applied directly to the conductor, which is tinned copper, Fig. 25.

All-asbestos-insulated cable, Fig. 26, is available to stand a temperature of 400 F indefinitely and voltages up to and including 7500 volts. Switchboard and rheostat wiring are also made with all-asbestos insulation, Fig. 27. On these wires and cables, inner insulation and outer covering is similar to that on asbestos varnished-cambric types.

Many single and multiple conductors are made for specific purposes. For example, Figs. 28 and 29 show single- and 2-conductor cables for use on run-out reels. The conductors are extra-flexible, stranded, rubber insulated. Over the rubber on the single-conductor design is a seine-twine braid treated with weatherproof compound. On the twin-conductor cable, a weatherproof cotton braid is placed over the rubber, then the two conductors are bound together with another weatherproof cotton braid over which is placed a weatherproof seine-twine braid. To obtain a round twin-conductor cable, concentric construction, Fig. 30, is used, insulated and protected as shown. Other types of wire and cable are insulated with rubber compound, protected by an outer covering of rubber which takes the place of the seine twine.

Cables made to be buried directly in the ground must withstand moisture, acids, alkalies, etc. Various types of cables are made for this purpose; the one in Fig. 31 gives a general idea of their construction. Conductors are solid or stranded annealed copper, rubber insulated.

For vertical-bore holes into mines, and for high-voltage in skyscraper buildings, cables are made with a steel-wire armor. This armor connects to a clamping device at the top end of the cable to support it from the top end of the bore hole or conduit. When the cable is to be installed in buildings, lead sheath is usually omitted.

A multitude of other cables and insulations are available for special applications and if you do not find what you need, ask the insulated-wire and cable manufacturers.

POWER CIRCUITS

■ AFTER POWER has been delivered to power-plant or substation busbars, it must be distributed to motors, heating units, lights and other devices. Selecting the wiring and other equipment necessary to transmit power to where it is used is just as important as choosing power-using apparatus. Electric-power installations are no better than their wiring; therefore, both should be of high quality and maintained in that condition. Under ordinary conditions, high-quality wiring requires very little attention.

Selecting wire and cable involves many factors, such as kind of insulation, how protected, ambient temperature, atmospheric and other deteriorating influences, operating voltage, whether dc or ac, importance of the installation, circuit load, length of circuit, National Electrical Code requirements, and other conditions.

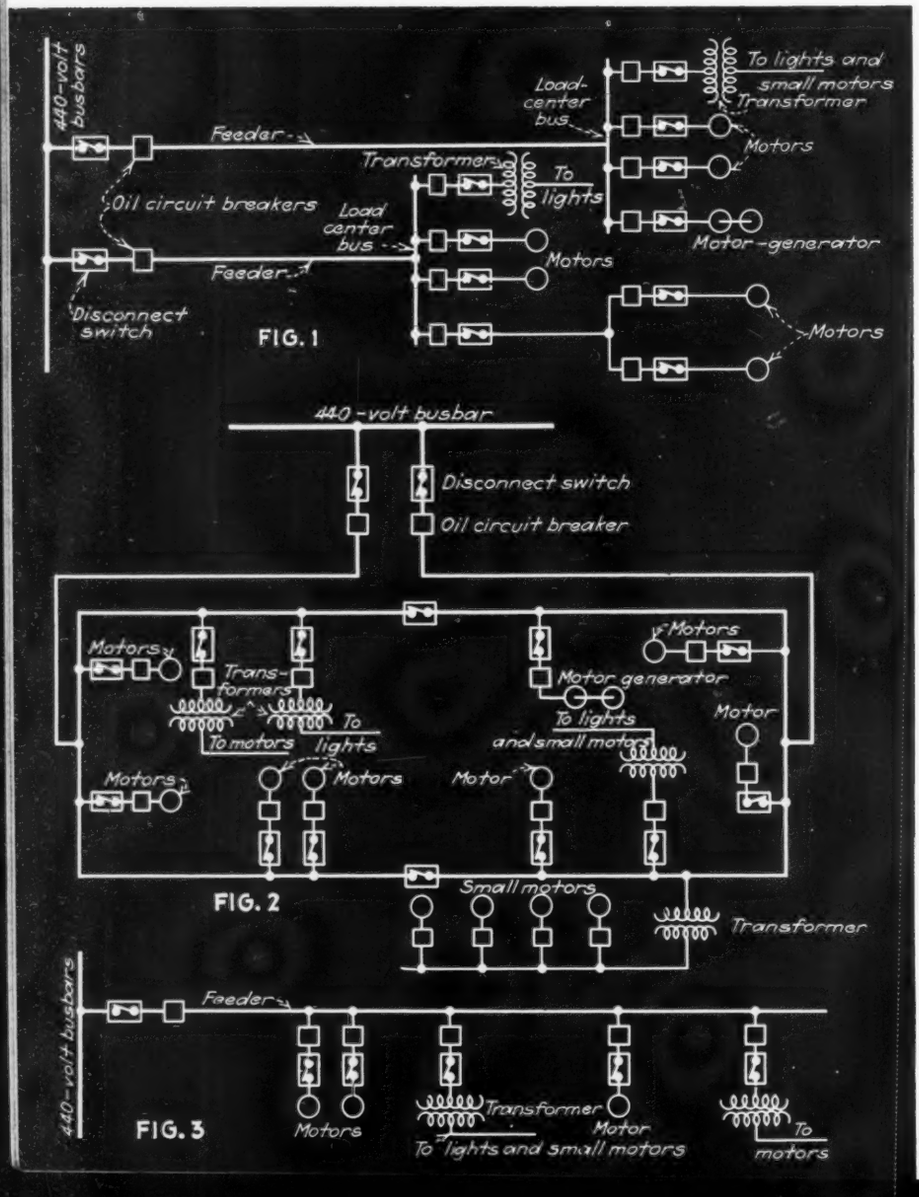
Four types of insulation—rubber, varnished cambric, paper, and asbestos are in general use. For 600 volts and less, rubber-insulated wire is used widely for motor and generator leads and for other power circuits where temperatures are normal. For sizes above No. 7, varnished-cambric-insulated wire finds wide application. Paper-insulated wire must always have an outside covering of lead and end in a pothead. If space is a factor, the smaller diameter of paper-insulated cable may overcome this objection, even for lower-voltage ranges. The range of 2300 to 15,000 volts finds paper-insulated cable in most wide use, although rubber, varnished cambric and other special compounds are also used in this range. In dry places where temperatures are high, asbestos-insulated wire finds wide use.

If wire is always in a dry place at normal temperatures, a single- or a double-cotton braid is sufficient covering over the insulation. The wire may be installed on knobs, supported in cleats or pulled into conduit. The latter is preferred because, with modern fittings, wire can be completely protected from mechanical injury.

When wiring is subjected to such deteriorating influences as high temperature, moisture, acids, alkalis, corrosive vapors, solvents, vibration, etc, insulation and protection must be selected to withstand these conditions.

On small and medium-size systems, power distribution is usually by a radial arrangement of feeders, Fig. 1, with no connection between the different feeders except at the main busbars. This system has the advantage of low cost, but if feeder to a load center fails, damage must be repaired before power can be restored. On the larger power systems, all load centers may be connected together by a loop feeder, Fig. 2, and power led from the main bus into this loop at several points. If a feeder or a section of the loop fails, it can be switched out and power still fed to all loads.

Fig. 1—Radial system of feeders for power distribution. Fig. 2—Loop-feeder system of power distribution. Fig. 3—Load distributed along a single feeder



Voltage Regulation

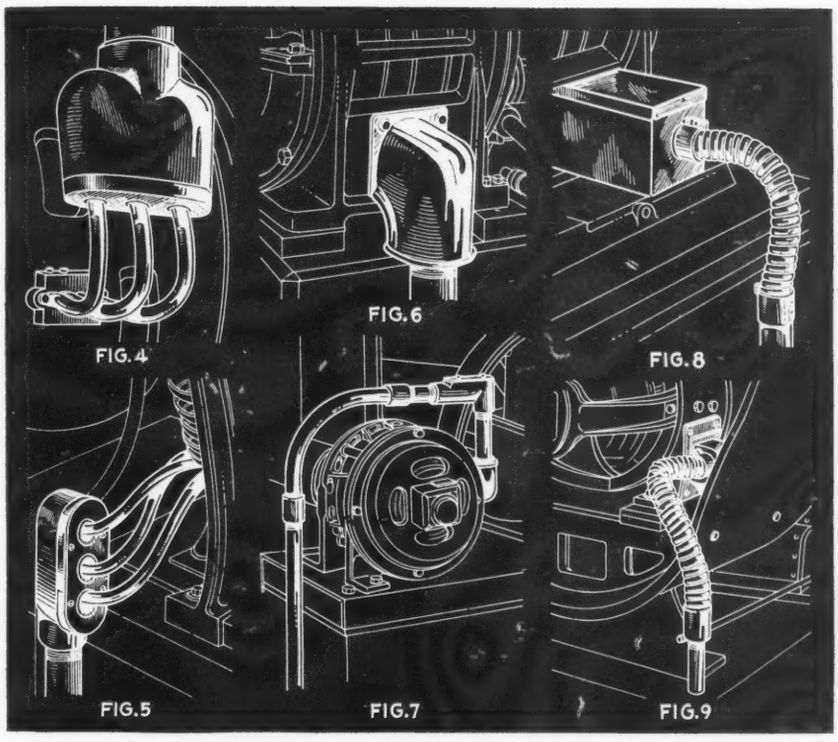
Good voltage regulation is important in laying out a feeder system. Generally, it is not advisable to run a long feeder and tap off it at several points, as in Fig. 3. Because of losses in the conductors, load at the feeder end may operate at much lower voltage than load nearest the power house. A better arrangement is to supply each load center by its own feeder, Fig. 1. Then the voltage at each load center can be made approximately equal, by feeder sizes and ratio taps on transformers.

The National Electrical Code should be followed in all cases unless superseded by a local code. It is now approved by the American Standards Association as an American standard and by many other bodies interested in safe standard wiring practices. The Code can be obtained from the National Fire Protective Assn, 60 Batterymarch St, Boston, Mass.

For distances up to several hundred feet, minimum size of wire recommended by the Code is usually ample, but long conductors must be selected on the basis of allowable voltage drop. Volts drop in a feeder for dc may be calculated by:

$$Ed = \frac{21.4\,L\,I}{CM}$$

where Ed equals voltage drop, L length



Figs. 4 and 5—Rigid conduit terminated away from motor. Figs. 6 and 7—Rigid conduit connects directly to motor-terminal box. Figs. 8 and 9—Flexible conduit connects rigid type to motor-terminal box

of conductor one way, *I* current in amperes, and *CM* circular-mil cross-sectional area of the conductors.

Assume power is to be supplied to a 230-volt, 100-hp motor 100 ft from the busbars and that voltage is 240 volts. Full-load current of this motor is 360 amp. The Code specifies that branch-circuit conductors supplying an individual motor in continuous-duty service shall have a carrying capacity not less than 125% of motor full-load current rating. Then, in this case, conductors must be selected for $360 \times 1.25 = 450$ amp. As given in the wire table, page 220, 600,000-cm is the minimum size rubber-insulated conductor permitted. Volts drop in this conductor based on full-load motor current is $Ed = \frac{21.4 \times 100 \times 360}{600{,}000} = 1.25$.

A 500,000-cm varnished-cambric-insulated wire is permissible on this circuit and with it, drop would be only 1.5 volts, a negligible value. The Code specifies a permissible voltage drop of 3% up to the final distribution point of the load. On a 240-volt circuit, this is $240 \times 0.3 = 7.2$ volts.

When feeders are selected for a group of motors supplied from one load center, the Code requires that the conductors shall be capable of carrying 125% of the largest motor full-load current plus full-load current of the other motors. Exceptions are when reduction of load results from a duty cycle, intermittent operation or all motors not operating at one time. Then conductor size may be reduced according to combined-load conditions.

Assume a feeder is to be selected for one 50-hp, one 40-hp and three 15-hp, 230-volt motors supplied from a load center 350 ft away from the power source. Rated full-load current of the 50-hp motor is 180 amp, 146 amp for the 40-hp motor, and 56 amp for each of the 15-hp motors. Combined current for selecting the minimum-size conductor is then $(180 \times 1.25) + 146 + (56 \times 3) = 539$ amp. For this load, the Code requires an 800,000-cm rubber-insulated or a 600,000-cm varnished-cambric-insulated wire. Voltage drop with the latter wire and assuming all motors fully loaded is $Ed = \frac{21.4 \times 350 \times 540}{600{,}000} = 6.74$, approximately 3%; therefore this size wire is satisfactory. From load center to each motor, the wire size will be selected on a basis of 125% of each motor's rated full-load current, as previously indicated.

For ac, selecting conductors becomes somewhat more involved because effects of inductance, number of phases, frequency and spacing of conductors must be taken into account. For example, assume that a 50-hp, a 40-hp, and three 15-hp, 440-volt 3-phase 60-cycle motors are to be supplied from a load center 350 ft from the power source. Total current on which size of conductor is based is determined in the same way as for dc.

Full-load rated current of a 50-hp, 3-phase, 440-volt motor is 63 amp, 51 amp for a 40-hp motor, 19 amp for a 15-hp unit. Then the minimum size of conductor will have to be good for $(63 \times 1.25) + 51 + (19 \times 3) = 187$, say 190 amp. No. 0000 rubber-insulated or No. 000 varnished-cambric-insulated conductor will meet this requirement. Voltage drop in the conductors is caused by ohmic resistance and inductance. That due to ohmic resistance of the No. 000 conductors to neutral is

$$Ed = \frac{10.7 \times 350 \times 170}{167{,}800} = 3.8 \text{ volts.}$$

Several methods have been developed for determining the inductive voltage drop, most of which are too long to discuss at any length here. One of the simplest is to obtain reactance-volts drop per amp from a table and make a simple calculation. For example, the reactance-volts drop per amp per 1000 ft of No. 000 conductor is 0.026. Then, in our problem, reactance-volts drop for one conductor is $0.026 \times 170 \times 350 \div 1000 = 1.15$ volts.

Reactance-volts drop is 90 deg out of phase with resistance-volts drop, therefore total-volts drop per conductor is equal to the square root of the sum of each squared. That is,

$$\sqrt{3.8^2 + 1.15^2} = \sqrt{(3.8 \times 3.8) + (1.15 \times 1.15)} =$$

approximately 4 volts. This value is for one conductor. For any two conductors in a 3-phase circuit, voltage drop is equal to that for one phase times 1.732, or in this case $4 \times 1.73 = 7$ volts. On a 440-volt circuit, this is a drop of $7 \div 440 = 1.6\%$, about one half that permitted by the Code. In conduit work, except for large long conductors, if a wire size is selected in which resistance-volts drop does not exceed 75% of that allowable, total voltage drop will be within a conservative value. For large conductors and those widely spaced, reactance-volts drop becomes important. On ac circuits don't use conductors larger than 400,000 cm, unless fiber cored.

Installing the conductors in conduit, although more expensive than open work, has the advantage that the conductors can be completely enclosed in metal from switchboard, through load center into the motor. When rigid conduit is terminated at electrical equipment such as motors, it should connect directly to the terminal box on the motor where possible, Figs. 6 and 7. Where the machine has to be moved on its base, a flexible connection is made between rigid conduit and motor, see Figs. 8 and 9.

ELECTRIC MOTORS

■ ALL TYPES of motors operate on the same fundamental principle—that an electric conductor carrying current in a magnetic field tends to move to cut the latter at right angles, as explained on page 203. Fig. 1 shows the field frame for a 4-pole interpole shunt motor with interpoles *A* and main poles *B*. Interpoles have a winding of comparatively large wire connected in series with the armature. These poles permit the machine to operate over its full-load range and in either direction with the brushes in a fixed position on the commutator. Because they help to improve operation of the brushes and commutator, they are frequently called commutating poles. On some machines, instead of concentrating all the commutating winding on interpoles, it is distributed in slots in the pole faces. Such a machine is known as a compensated type.

The main poles *B*, Fig. 1, have shunt windings of many turns of small wire and a light series winding of a few turns of comparatively heavy wire. The shunt winding produces the main magnetizing force to excite the field poles and the series winding serves to make operation more stable under fluctuating loads.

Fig. 2 is a dc-motor armature in which an insulated winding is laid around the periphery of a laminated core in slots. The winding connects to a commutator made up of copper segments insulated from each other, with the exception of circuits through the winding.

Direct-Current Motors

Dc motors are of three general types: **series**, **shunt** and **compound.** The series motor has field coils wound with comparatively large wire and connected in series with the armature, Fig. 7, Table I. This motor has high starting torque but will race if lightly loaded, unless controlled. The shunt motor has a comparatively high-resistance field winding connected in parallel with the armature, Fig. 8, Table I. Because its speed is practically constant from no load to full load and can be adjusted over a wide range when the motor is properly designed, this type has come into more general use than any other dc motor.

Where constant speed with high starting torque is required, a compound motor is used, Fig. 9, Table I. A series and a shunt winding on main field poles give it high starting torque with fairly constant speed. In some cases the series winding is used for starting only and is cut out of circuit as the motor comes up to speed. Other characteristics of these motors and typical applications are given in Table I.

Ac motors are of three general classes: **induction**, **synchronous** and **commutator.** These, however, may be sub-divided into many other types according to the number of phases, structural features, method of starting, speed control, characteristics, etc. Two- and 3-phase motors are classed as polyphase. The simplest of these and the one most generally applied is the induction squirrel-cage motor. In this design, power current is supplied to a winding in the stationary part of the machine, known as the stator, Fig. 3. For a 3-phase motor, three groups of winding are placed in the stator core, and for 2-phase, two separate windings.

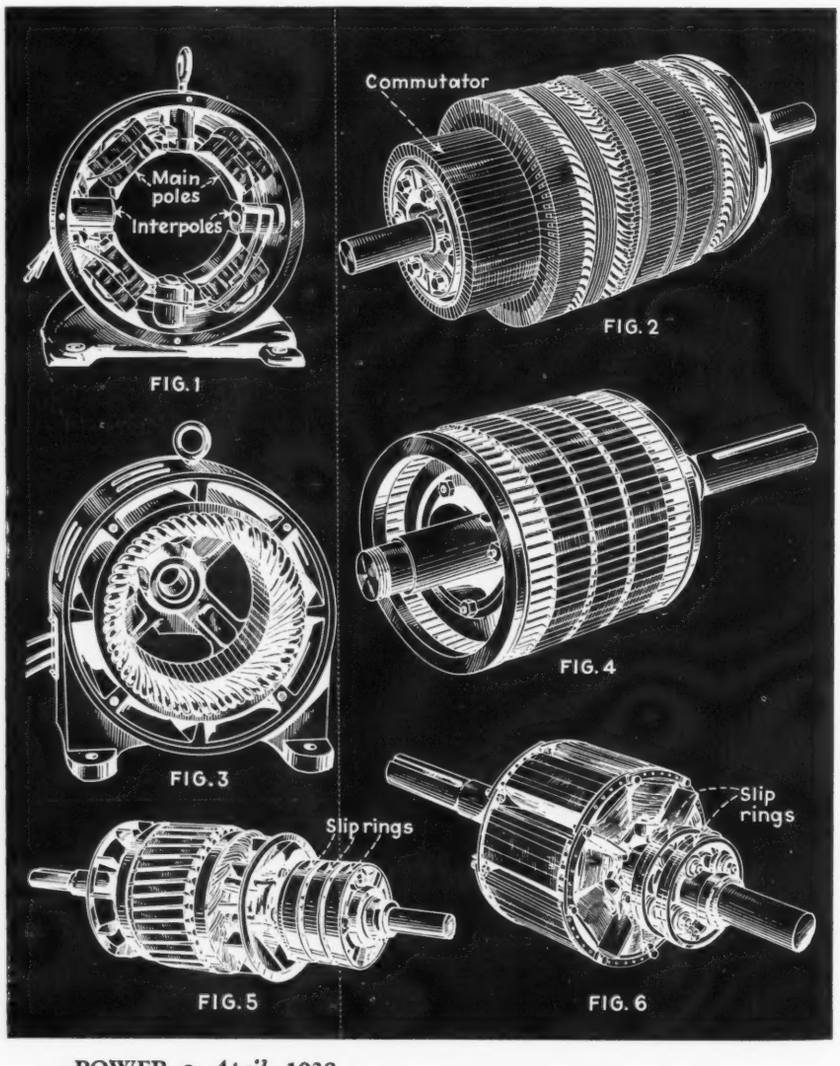
The rotating element (rotor) of a squirrel-cage motor is a laminated iron core with slots in its periphery in which copper bars are placed and connected to a ring at each end, Fig. 4. This winding looks like a squirrel cage, from which the name.

Squirrel-Cage Rotor

The rotor winding has no direct connection to the power source, but has current induced in it by action of the rotating-magnet field produced by the current in the stator winding. Current in the rotor bars acts on the stator field somewhat as in a dc motor and the rotor revolves at practically the same speed as the magnetic field.

There are several squirrel-cage motors, such as general purpose, Fig. 13;

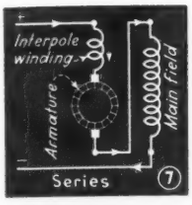
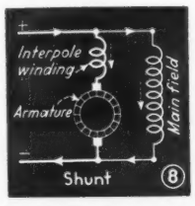
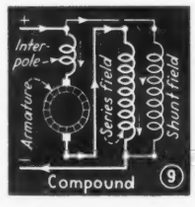
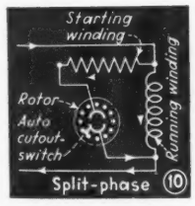
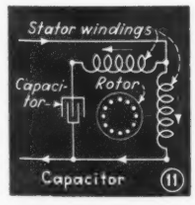
Fig. 1—Field structure of a shunt interpole dc motor. Fig. 2—Dc motor armature. Fig. 3—Induction-motor stator. Fig. 4—Squirrel-cage rotor for industrial motor. Fig. 5—Wound rotor for induction motor. Fig. 6—Synchronous-motor rotor



line-start high-torque, Fig. 14; line-start low torque, Fig. 15; and line-start high-slip, Fig. 16. Characteristics and typical applications are given in Table II. In addition to designs given in Table II, other forms have been developed such as double-squirrel-cage and multiple-speed types. The latter have their stator windings so arranged that they can be regrouped by control to give two or four fixed speeds. For some applications where speed-adjustment requirements are not very exacting; such as on fan drives and on slow- and medium-speed elevators; multi-speed motors are used quite extensively.

To meet requirements of high starting torque with low starting current, a wound-rotor induction motor has been developed. This motor has a stator winding similar to the squirrel-cage type, Fig. 3; but the rotor has a 3-phase insulated winding connected to three slip rings, Fig. 5. These rings connect through brushes to an external resistance, Fig. 17, Table II. To

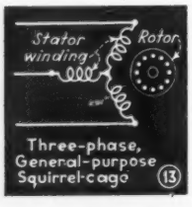
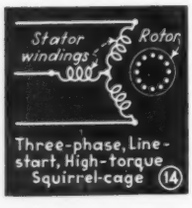
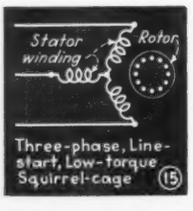
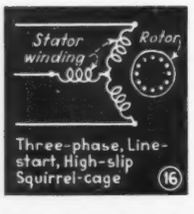
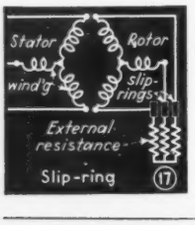
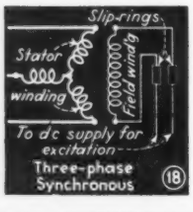
Table I—Diagrams, Characteristics and Applications of DC and Single-Phase AC Motors

Diagram and Type	*Ratings Hp*	*Speed Regulation*	*Speed Control*	*Starting Torque*	*Pull-Out Torque*	*Applications*
	Fractional to several hundred	Varies inversely as the load. Races on light loads and full voltage	Zero to maximum depending on control and load	High. Varies as square of the voltage. Limited by commutation, heating and line capacity	High. Limited by commutation, heating and line capacity	Where high starting torque is required and speed can be regulated. Traction, bridges, hoists, gates, car dumpers, car retarders, etc
	Fractional to several thousand	Drops 3 to 5% from no load to full load	Any desired range depending on motor design and type of system	Good. With constant field, varies directly as voltage applied to armature	High. Limited by commutation, heating and line capacity	Where constant or adjustable speed is required and starting conditions are not severe. Fans, blowers, centrifugal pumps, conveyors, wood-working machines, metal-working machines, elevators, line shafts
	Fractional to several thousand	Drops 7 to 20% from no load to full load depending upon amount of compounding	Any desired range, depending upon motor design and type of control	Higher than for shunt, depending upon amount of compounding	High. Limited by commutation, heating and line capacity	Where high starting torque combined with fairly constant speed is required. Plunger pumps, punch presses, shears, bending rolls, geared elevators, conveyors, hoists
	Fractional to 5 hp	Drops about 10% from no load to full load	None	75% for large to 175% for small sizes	150% for large to 200% for small sizes	Constant-speed service where starting is easy. Small fans, centrifugal pumps and light-running machines, where polyphase current is not available
	Fractional to 15 hp	Drops about 5% for large to 10% for small sizes	None	150 to 350% of full load depending upon design and size	150% for large to 200% for small sizes	Constant-speed service for any starting duty and quiet operation, where polyphase current cannot be used
	Fractional to 40 hp	Drops about 5% for large to 10% for small sizes	Repulsion-induction, none. Brush-shifting types, 4 to 1 at full load	250% for large to 350% for small sizes	150% for large to 250% for small sizes	Constant-speed service for any starting duty where speed control is required and polyphase current cannot be used

start the motor, the line switch is closed to energize the stator winding and then external resistance is gradually cut out of circuit as the rotor comes up to speed. These motors at starting will develop about 275 to 300% full-load torque on 300% full-load current. Motor speed may be regulated down to about 50% rated value by rotor-resistance control and for some applications such as fans, pumps, conveyors, etc, this speed regulation gives a satisfactory range.

Synchronous motors are ac generators specially designed to operate as motors. Stator is similar to that in an induction motor, Fig. 3, but the rotor, Fig. 6, has field poles like a dc motor

Table II—Diagrams, Characteristics and Applications of Polyphase AC Motors.*

Diagram and Type	*Ratings Hp*	*Speed Regulation*	*Speed Control*	*Starting Torque*	*Pull-Out Torque*	*Applications*
	0.5 to 200 hp	Drops about 3% for large to 5% for small sizes	None, except multi-speed types, designed for 2 to 4 fixed speeds	200% of full load for 2-pole to 105% for 16-pole designs	200% of full load	Constant-speed service where starting torque is not excessive. Fans, blowers, rotary compressors, centrifugal pumps, wood-working machines, machine tools, line shafts, light conveyors
	0.5 to 100 hp	Drops about 3% for large to 6% for small sizes	None, except multi-speed types, designed for 2 to 4 fixed speeds	250% of full load for high-speed to 200% for low-speed designs	200% of full load	Constant-speed service where fairly high starting torque is required at infrequent intervals with starting current of about 400% of full load. Reciprocating pumps and compressors, conveyors, crushers, pulverizers, revolving screens, agitators, milling machines, etc
	0.5 to 100 hp	Drops about 3% for large to 5% for small sizes	None, except multi-speed types, designed for 2 to 4 fixed speeds	50% of full load for high-speed to 90% for low-speed designs	150 to 170% of full load	Constant-speed service where starting duty is light. Fans, blowers, centrifugal pumps and similar loads
	0.5 to 150 hp	Drops about 10 to 15% from no load to full load	None, except multi-speed types, designed for 2 to 4 fixed speeds	225 to 300% of full load, depending on speed with rotor resistance	200%. This motor will usually not stall until loaded to its maximum torque, which occurs at standstill	Constant-speed service and high starting torque, if starting is not too frequent, and for taking high-peak loads with or without flywheels. Punch presses, die stamping, shears, bulldozers, elevators, hoists, bailers, metal drawing, etc
	0.5 to several thousand	With rotor rings short-circuited, drops about 3% for large to 5% for small sizes	Speed can be reduced to 50% of normal by rotor resistance to obtain stable operation. Speed varies inversely as the load	Up to 300% depending upon external resistance in rotor circuit and how distributed	200% when rotor slip rings are short circuited	Where high starting torque with low starting current or where limited speed control is required. Fans, centrifugal and plunger pumps, compressors, conveyors, hoists, cranes, lift bridges, metal-rolling mills, rotary car dumpers, ball mills, gate hoists, etc
	25 to several thousand	Constant	None, except special motors designed for 2 fixed speeds	40% for slow-speed to 160% for medium speed 80%-pf designs. Special designs develop still higher starting torques	Unity-pf motors 170%; 80%-pf motors 225%. Specials designs up to 300%	For constant-speed service, direct connection to slow-speed machines and where power-factor correction is required. For application see table page 211

* The same data applies to 2-phase motors that is here given for 3-phase designs.

which are excited from a dc source, either a small generator driven by the motor or from an outside supply. When field poles are excited, their *N* and *S* poles lock with *S* and *N* poles respectively of the stator's rotating magnetic field and are driven at the same speed. As originally designed, this type of motor had low starting torque (which limited its use), but motors have been developed for a wide variety of industrial-drive applications and power-factor requirements, as shown in the synchronous-motor-application table, published by courtesy of Electric Machinery Mfg Co. Synchronous motors may be grouped in two clasifications: unity power-factor and 80% power-factor machines. The former are used where a normal amount of power-factor correction is needed and the latter where power-factor correction requirements are large. They also serve many conditions of starting torque and pull-in torque requirements. One design, known as the super-synchronous motor, can start and pull into step loads up to the limit of its pull-out torque. 2-speed designs are available to operate part of the time at half speed.

Fynn-Weichsel Motor

Size limits of synchronous motors are about 25 hp and above in slow-speed designs and about 75 hp for higher speeds. The Fynn-Weichsel induction-synchronous motor meets the demands for power-factor control below economic sizes of synchronous types. This motor is very much like a wound-rotor motor, but has also an exciter winding on the rotor connected to a commutator. It is started as a wound-rotor motor and, when the rotor reaches about 95% full speed, pulls into synchronism and operates at synchronous speed. At full load, its power factor is unity and at light loads decidedly leading, similar to a unity-power-factor synchronous motor.

Speed Adjustment

Speed adjustment up to 4 to 1 is possible with commutator-type polyphase motors. These motors have a stator like an induction motor and an armature like a dc motor. Low-voltage current is supplied to the rotor by the secondaries of current transformers having their primaries connected in series with the stator power leads. Speed adjustment is obtained by shifting the position of the brushes on the commutator. Where adjustable speed is required of an ac motor, frequently the most economical answer to the problem is a simple squirrel-cage motor and some form of variable-speed transmission.

Recently, an adjustable-speed polyphase commutator-type motor has been made available in sizes up to 7.5 hp. This motor operates with brushes in a fixed position and has its speed controlled by an induction-type regulator connected into the armature circuit. Its speed can be regulated from slightly above standstill to 50% above synchronous speed by simply turning the speed regulator through 180 deg. At speeds below synchronous, slip energy, which in the ordinary slip-ring motor is dissipated in the external resistance, is returned to the line through the speed regulator. At speeds above synchronous, part of the energy for driving the motor is supplied to the stator and part to the rotor winding.

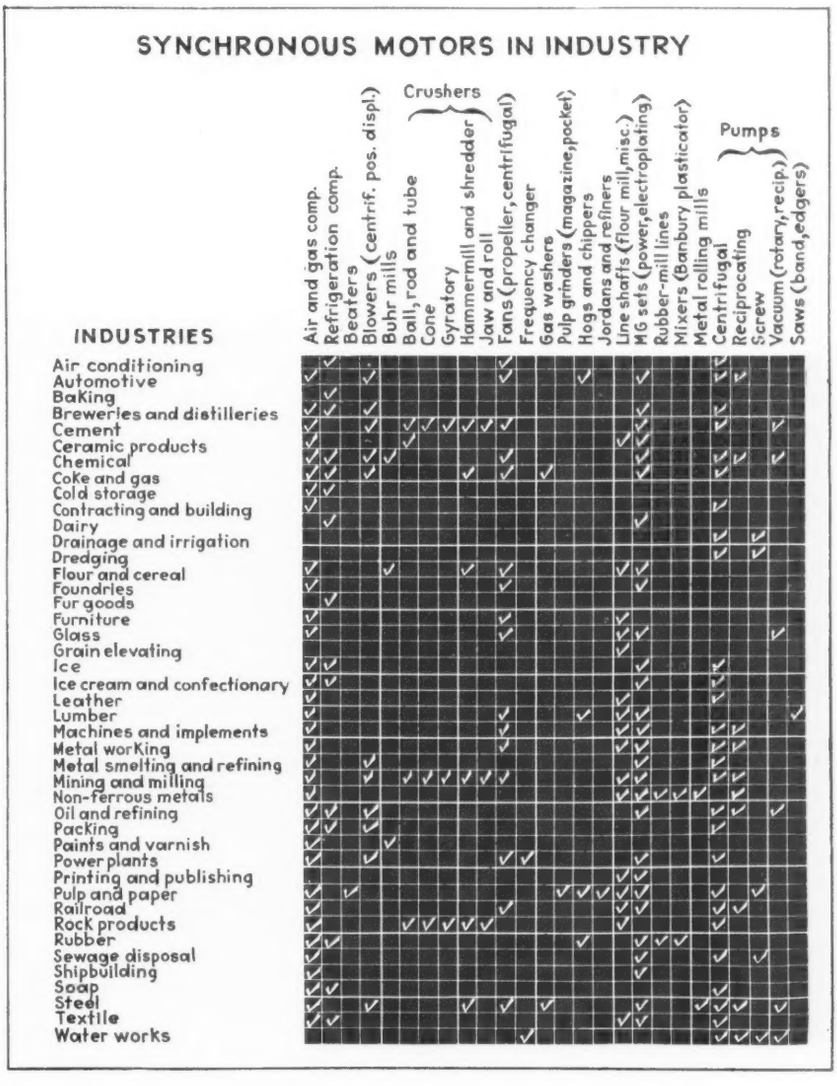
Split-Phase Motors

For small power applications and where polyphase current is not available, single-phase motors are used. A simple single-phase squirrel-cage motor is not self starting, but will continue to run when brought up to speed. In the split-phase design, Fig. 10; Table I, a high-resistance starting winding is added to the stator and connected in parallel with the running winding. These two windings during starting produce an effect similar to a 2-phase motor, except that the starting torque is lower. An automatic switch cuts out the starting winding as the rotor approaches full speed.

Capacitor Motor

Similar results are obtained, except with a higher starting torque, with the capacitor motor Fig. 11, Table I. On some designs the capacitor winding is left in circuit and in others it is cut out after the motor comes up to speed. Commutator-type single-phase motors, Fig. 12, Table I, are available in several forms. These have a wound rotor like a dc motor with brushes on the commutator that are short-circuited. On some types, the brushes remain on the commutator all the time. In the repulsion-induction type, brushes are lifted after the motor has almost reached full speed and the commutator short circuited automatically.

Many more types of motors are in use than mentioned here, but those described give a general picture of what is available and where used.



MOTOR CONTROL

■ EXCEPT FOR fractional-hp sizes, all dc motors must be started with resistance in their armature circuit. A 5-hp, 220-volt dc motor takes a full-load current of 20 amp and may have an armature resistance of 1 ohm. If connected directly to a 225-volt line at standstill, the inrush current would be about $225 \div 1 = 225$ amp. This motor would be fused for 25 amp. To keep the current within safe limits, a resistance is connected in series with the armature and then gradually cut out as the motor comes up to speed.

Fig. 1 shows a manual starter connected to a shunt motor. If this is the 5-hp motor just mentioned, then starting current must be kept to 25 amp, which on a 225-volt circuit will require $225 \div 25 = 9$ ohms resistance. As the armature has one ohm resistance, starting resistance will be 8 ohms. As the armature accelerates, it generates a voltage that opposes the line voltage. When the counter voltage reaches 45, volts effective in causing current to flow in the circuit drop to $225 - 45 = 180$. With 9 ohms resistance in the circuit, current drops to $180 \div 9 = 20$ amp.

Now, if resistance is reduced 1.5 ohms by moving the starter arm to No. 2 contact, total circuit resistance will be $9 - 1.5 = 7.5$ and the current will increase to $180 \div 7.5 = 24$ amp, which will cause the armature to accelerate to a higher speed. This illustrates the process of accelerating a dc motor and what happens during acceleration.

When the starting arm is in position to cut out all resistance, it is held there by the no-voltage-release magnet. The coil of this magnet, in series in the field circuit, provides no-voltage and open-field-circuit protection. If power supply fails, the starter arm is returned by a spring to the off position. This prevents fuse blowing or injury to the motor if the starter arm should remain in *on* position and power return.

For manual starting and control, a drum-type controller, Fig. 2, is used. Motor and resistance connect to stationary fingers which are picked up by contacts on a drum rotated by a crank. To provide no-voltage release, two additional fingers F_5 and F_6 connect to a magnetic-contactor coil. When the cylinder is moved to point No. 1, it picks up fingers F_1, F_2, F_5 and F_6. Closing F_5 and F_6 connects coil C across the line and closes C_1 contact to complete the power circuit. Auxiliary contact A closes and completes a holding circuit for coil C, so that when the control is moved to points 2, 3 and 4 with F_5 and F_6 open, contactor C_1 remains closed.

Closing contacts F_1 and F_2 connects the motor field across the line with the starting resistance in series with the armature. As the motor accelerates, the controller is moved to point 2 and picks up finger F_3, thereby shortcircuiting one section of starting resistance. Point 3 on the control picks up finger F_4 and point 4, finger F_5, to shortcircuit all starting resistance and bring motor to full speed. If power fails while the motor is running, contactor C opens, but cannot close again, because its coil circuit is open at A, F_5 and F_6, until the control is returned to starting position. This prevents connecting the motor to the line without having starting resistance in the circuit.

For many applications, it is desirable to start and stop motors automatically, which means starting and control equipment with contactors operated by magnets. Such controls are of two general classes: push button and full automatic. Usually, a push-button control is pressed momentarily to start the motor and another button pressed to stop it. For some special applications, the motor runs only as long as the button is pressed.

Automatic Starters

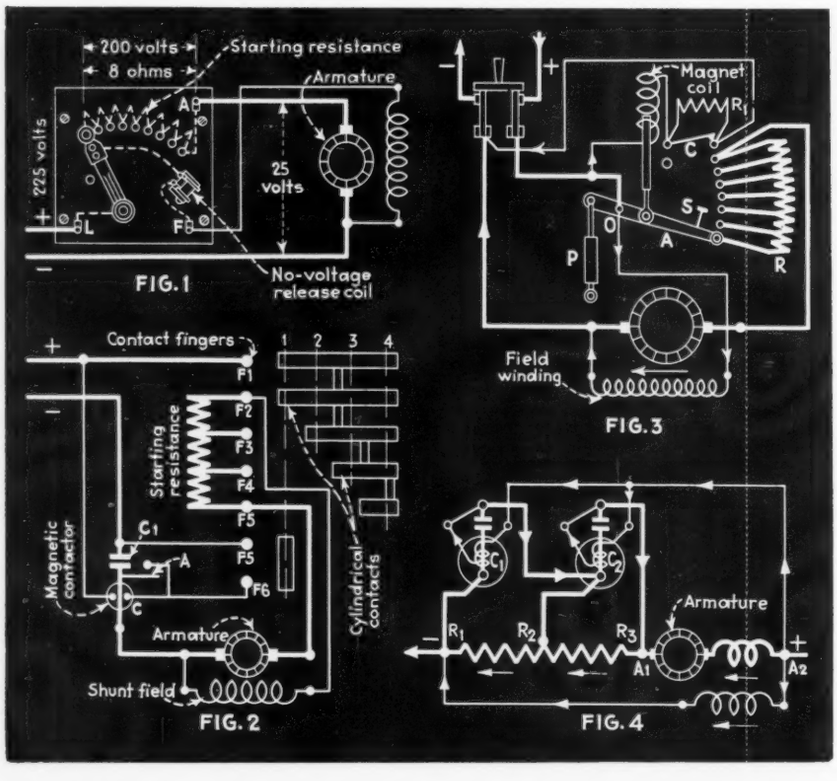
Several methods of acceleration are used in automatic starters. One of these, the time-limit, is illustrated in Fig. 3. This starter is very much like Fig. 1, with a solenoid to pull up the starter arm and cut out the starting resistance. In this simple arrangement, the motor starts when the line switch is closed. Arrow heads indicate circuits, with arm A on the first point of the starting resistance.

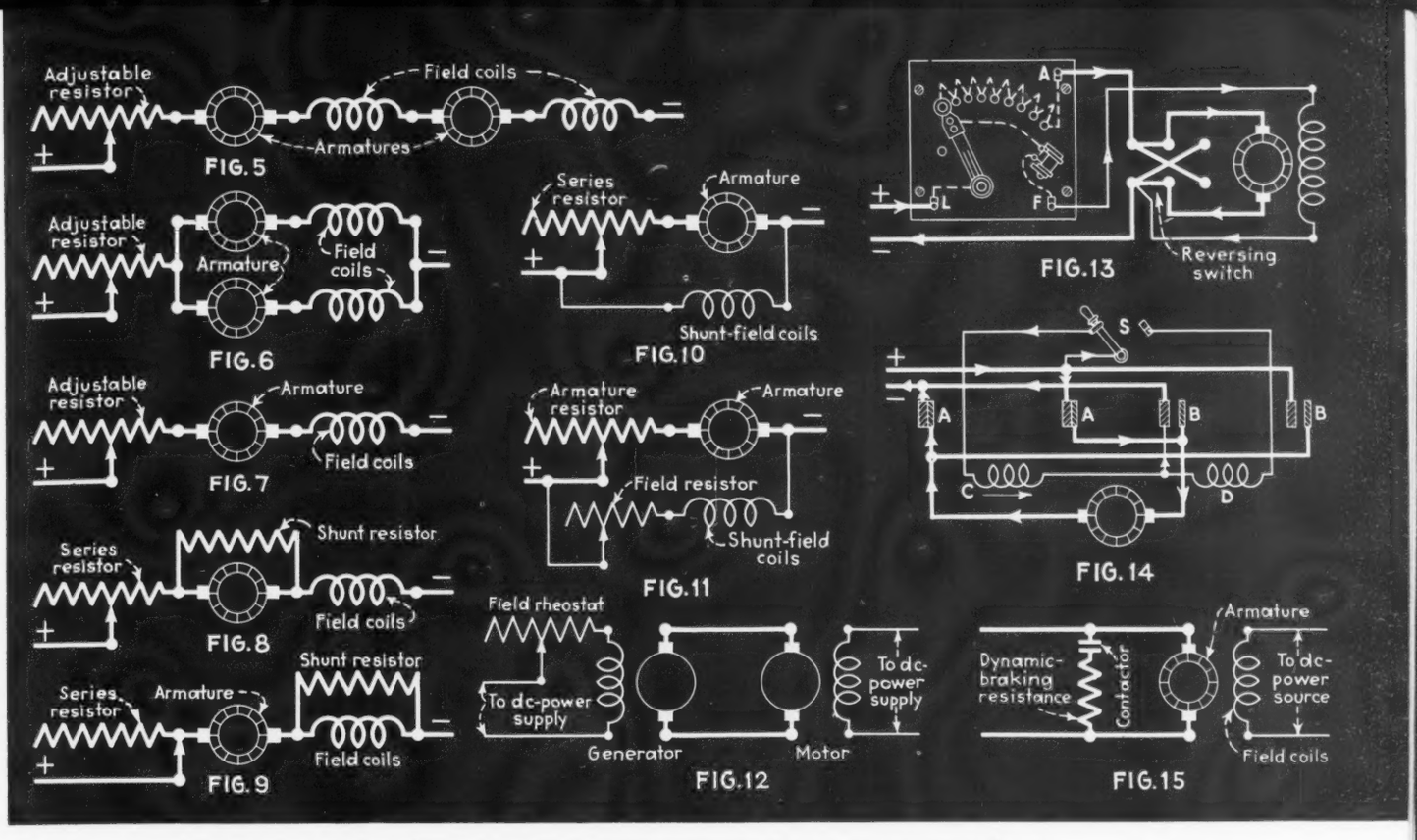
The magnet coil connects directly across the line and swings arm A up across the starting-resistance contacts around point O. Left-hand end of arm A connects to an oil dashpot P, which retards arm motion so that starting resistance will not be cut out too quickly. An adjustment on the dashpot permits changing the rate at which resistance may be cut out.

Contact C shortcircuits resistance R_1 out of the magnet-coil circuit during starting. When arm A reaches the top of its travel, stud S lifts C, puts resistance R_1 in the coil circuit and reduces current in coil C to a value just sufficient to hold the arm in the *on* position.

By adding a magnetic contactor to open and close the power circuit (Fig. 2) and connecting a float switch, pressure switch or other starting device in

Fig. 1—Face-plate manual starter and shunt motor. Fig. 2. Cylindrical manual starter and shunt motor. Fig. 3. Time-limit automatic starter. Fig. 4. Counter-electromotive-force automatic starter





Figs. 5 to 9—Speed-control methods for series motors. Figs. 10 to 12—Methods of shunt-motor speed control. Figs. 13 and 14—Reversing switch connected for shunt motors. Fig. 15—Dynamic-braking resistor connected across shunt-motor armature

the contactor circuit, the starter (Fig. 3) can be made fully automatic. Several forms of time-limit starters have been developed, of which Fig. 3 shows the general principle.

One method of accelerating a motor according to load utilizes the counter-electromotive principle, Fig. 4. Arrows show circuits when the line switch closes. Contactor coil C_2 is connected directly across the armature, coil C_1 across the armature and resistance R_2-R_3. Thus, if the switch is closed on a 225-volt circuit, assume voltage divides so that 25 volts go across the armature and 100 across each section of resistance. Then coil C_2, which is connected to the armature, will have 25 volts impressed on it, and coil C_1, $25 + 100 = 125$ volts. This, however, is not sufficient to close the contactors, which we will say requires 145 volts.

When the motor accelerates to where volts across the armature increase to 65, there will be 80 across each section of resistance, assuming that each section is equal, generally not true in practice. Then coil C_1 will have $80 + 65 = 145$ volts across its terminals and will close its contactor. As the armature continues to accelerate, voltage across its terminals increases until it reaches a value that closes contactor C_2 to cut out all the resistance. The motor then comes to full speed.

Speed control depends upon type of motor and kind of service. Where two or more series motors drive a common load, as on a trolley car, motors may be operated in series, with or without series resistance, for low speed, Fig. 5, and in parallel for high speed, Fig. 6. For single motor drive, speed control may be obtained by an adjustable series resistor, Fig. 7, or a combination of series and shunt resistors, Fig. 8. These methods regulate speed from zero up to full load value of the motor. To increase the speed of a loaded series motor above full-load value, a resistor is shunted across the field winding, Fig. 9.

Shunt Motor

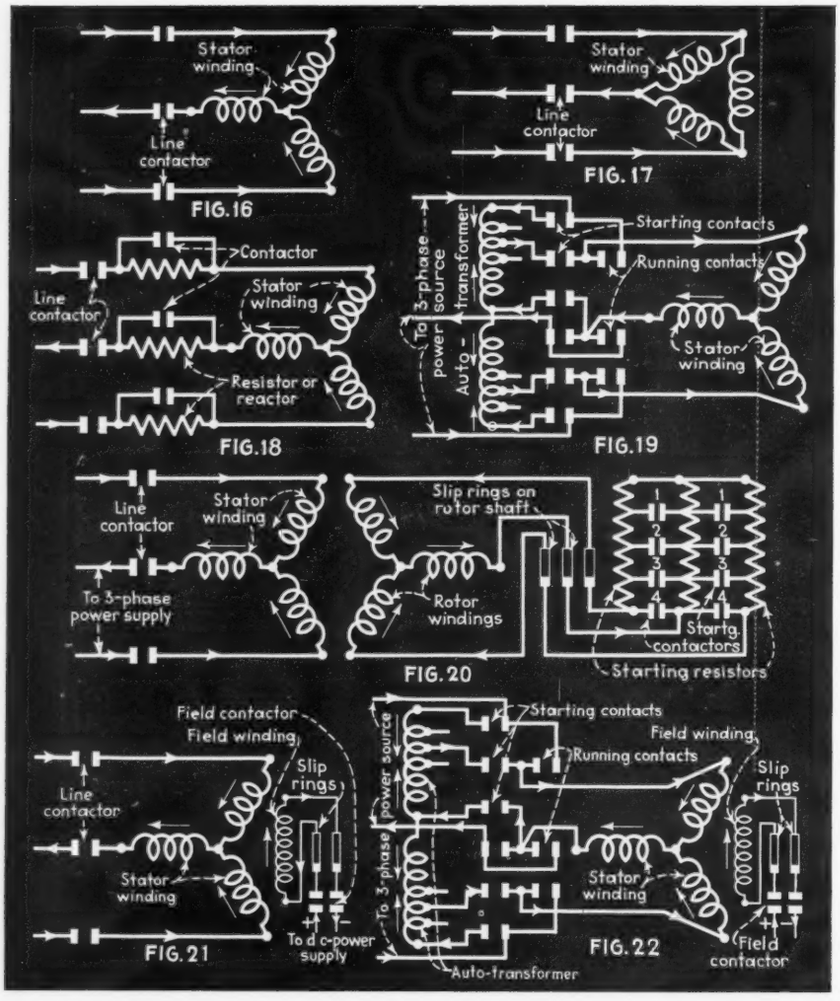
Speed of a shunt-motor may be controlled from zero up to full-load value by series armature resistance, Fig. 10. Constant speed at any setting depends upon constant load. Speeds above full-load value may be had by putting a rheostat in series with the field windings, Fig. 11. Speed ranges of 1 to 6 have been obtained by field control of specially designed shunt motors. Generally armature-resistance and field-resistance control are combined for speed ranges above 1 to 4.

Where close control is required at very low speed, the armature may be shunted by a resistance, as, for example, on the series motor, Fig. 8. When field- and armature-resistance speed control will not meet the requirements, variable voltage control is used, Fig. 12. In this system each motor is supplied by power from its own generator. Starting, accelerating, stopping and speed control of the motor is accomplished by adjusting generator-field current with a rheostat.

When motors are required to operate in either direction, reversing is done with a switch. For occasional reversal with manual control, a double-throw switch, connected as in Fig. 13, will do the trick. Arrows indicate direction of current flow through the armature for one switch position. Throwing the switch to the right will reverse direction of armature current. Manual = reversing controllers are commonly of the cylindrical type, similar to Fig. 2, except that they are turned in one direction from the off position for one motion of the armature and in the other direction for reverse rotation.

On automatic control, armature reversal is usually accomplished with two magnetic switches, one closing for one direction and the other for reversal, Fig. 14. One magnet coil and armature circuit is shown in the figure. Throwing direction switch S to the right will energize coil D to close contacts B, when contacts A open. With variable-voltage control, motor-armature reversal is accomplished by reversing generator-field current.

If motors are frequently started and stopped, as in elevator and hoist service, a large part of the braking during stopping is usually done by reversal of starting operations or by connecting a resistance across the armature Fig. 15, or a combination of the two. Connecting resistance across the armature causes the motor to become a generator, thereby producing a



Figs. 16 and 17—Connections for starting squirrel-cage motors on full voltage. Figs. 18 and 19—Reduced-voltage starting of squirrel-cage motor. Fig. 20—Diagram of wound-rotor motor with external starting resistance. Figs. 21 and 22—Connections for starting synchronous motors

braking action (dynamic braking) inversely proportional to circuit resistance. This method of stopping controls retardation with a minimum of wear on the mechanical brake.

It is general practice to start squirrel-cage and synchronous ac motors by connecting them directly to the line if power system and other conditions permit. To start a squirrel-cage motor in this way, a simple switch, Fig. 16, either hand or magnetically closed, is sufficient. This throws full voltage on the stator winding, causes a maximum current to flow and develops maximum starting torque. Simple starting equipment is very desirable, as evidenced by the trend toward full-voltage starting of squirrel-cage motors.

Several methods of reduced-voltage starting are in use. One is to design motor windings so that they are connected in star, Fig. 16, for starting; and delta, Fig. 17, for running. This method is suitable only where starting is comparatively easy, because starting torque with the star connection is only 33% of delta-grouping torque.

Resistors or reactors in series with the stator winding, Fig. 18, are used to reduce voltage at motor terminals for starting, but have the disadvantage of taking full value of starting current from the line. Auto-transformers overcome this objection by reducing starting current taken from the line practically in proportion to the transformer ratio. If starting voltage is 75% line voltage, then current taken from the line equals 75% of the current supplied to the motor. Fig. 19 shows connections for starting a 3-phase squirrel-cage motor with two auto-transformers. Taps give a starting voltage of about 65 to 85% of line voltage, depending upon starting torque required. On the diagram, arrows indicate current flow at one instant with starting contacts closed.

Wound-rotor motors supply requirements of high starting torque with low starting current. This motor has an insulated winding on the rotor connected to an external resistance through slip rings and brushes on the motor shaft, Fig. 20. At starting, the line contactor is closed first to energize the stator windings. Then, starting contactors 1, 2, 3 and 4 are closed in sequence to shortcircuit resistors out of the rotor as it accelerates. The same arrangement will vary motor speed, but external resistors must be designed for speed-control service.

Any of the foregoing methods of starting ac motors can be obtained in manual or automatic forms for any desired application. They may also include means for reversing direction of rotation, which on a 2-phase motor is done by crossing the leads in either phase, and on a 3-phase motor, by crossing any two of the three motor leads.

Synchronous Motors

Synchronous motors are started either by connecting stator windings directly to the line, Fig. 21, or to reduced voltage obtained through auto-transformers, Fig. 22. Synchronous motors are also started by the part-winding method. The stator winding is grouped in two or more parts and terminals brought to the outside, so that one section of the winding can be connected in for starting and the others added as the rotor accelerates.

Whatever the method of starting, the field circuit must be closed when the rotor approaches synchronism so that it will pull into step. With manual starting, the field switch is usually closed by hand and the time of closing is a matter of operator's judgment. When starting automatically, timing relays of various types close the field circuit at the proper time to give maximum pull-in torque.

Speed Adjustment

As explained in "Electric Motors," wide speed adjustment is not easily obtained with ac motors except by special design. For constant load, wound-rotor motors may be slowed down to about 50% of synchronous speed and squirrel-cage motors may be wound to give two or more fixed speeds. Special speed-regulating sets have been developed, but they are limited to large capacity drives and are complicated and expensive. Adjustable-frequency systems are used for certain applications, but this requires a source of adjustable-frequency power. Where wide range of speed adjustment is required, common practice is to convert ac power to dc and then use dc motors and one of the methods of speed control described for this type of motor.

Single-phase motors are usually small and started by connecting directly to the line, either by a manual switch or pushbutton. Automatic starting and stopping may be obtained by a float, pressure, temperature or other type of switch.

PF CORRECTION

■ POWER FACTOR of an ac system may be defined as the ratio of true power (kilowatts) indicated by a wattmeter to the apparent power (kilovolt-amperes) calculated from voltmeter and ammeter readings. That is, *power factor, pf = kilowatts ÷ kilovolt-amperes.* For example, if the wattmeter on a single-phase circuit indicated 16 kw and the product of voltmeter reading (200) and ammeter reading (100) 200 × 100 ÷ 1,000 = 20 kva, then pf = 16 ÷ 20 = 0.80. For most loads, power factor is less than 1.00, and is usually lagging.

Power factor of a power system will depend upon the type of load. Incandescent lamps, being largely a resistance load, operate at nearly unity pf. On the other hand, induction motors, which have high inductance because of the iron in their cores, will have a lagging pf of from 0.30 or less to 0.90 or higher depending on size, speed and how nearly they are fully loaded.

Low pf load is objectionable for several reasons: 1. Generators, transformers and power lines must be larger to supply a given load. 2. Losses in generators transformers and lines increase. 3. Causes poor voltage regulation. 4. Decreased voltage may cause poor operation of equipment on the line. 5. Low voltage may cause reduced speed of motor and decrease output of driven machines. 6. When power is purchased, rates are frequently increased if the load pf is less than a given value and decreased if above that value.

For these reasons, it is frequently desirable to correct pf if it is below 0.80 or 0.85. How to correct pf will depend upon conditions in the plant. Extensive use of induction motors and a general tendency to overmotor are the chief causes of low pf. Therefore, in considering pf correction, first give attention to a better loading of motors. In some plants, pf has been considerably improved by interchanging motors. For example, 5-hp motors might replace 10-hp units and 10-hp motors transferred to machine drive by 15-hp units. Except under favorable conditions and with high-speed motors, pf of induction-motor load will seldom be much above 0.80.

Where machines require motors of 50-hp or more capacity, it may be economical to replace induction motors with synchronous machines. These motors are of two general types: those designed to have unity full-load pf and those that have 80% leading pf at full load. The latter are more expensive motors, but when a maximum pf correction is required, they should be selected.

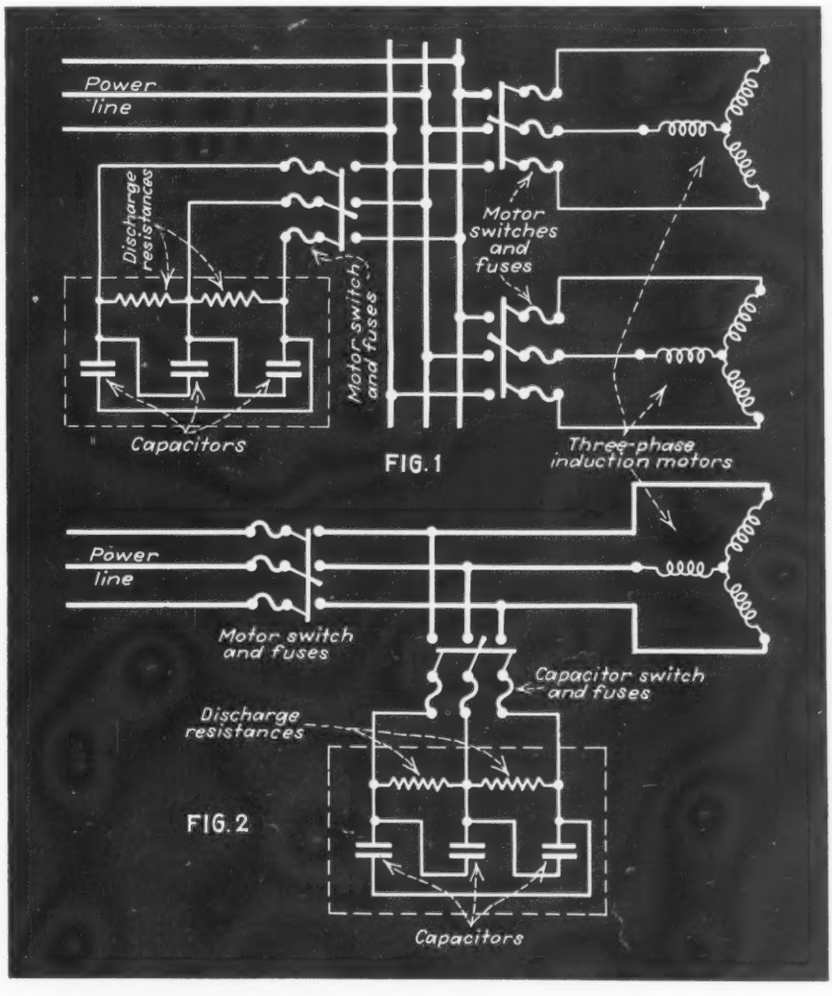
If all motors are small, a combination of induction and synchronous-induction types may be used to obtain good pf. Another way to correct pf where all motors are small induction units is to use capacitors (static condensers), which should be placed as near as possible to the source of low pf. For example, if a feeder supplies a group of motors from a distributing panel, connect the capacitors to the distribution bus, Fig. 1. Or, divide capacitors into smaller units and connect them to terminals of individual motors. In either case, pf is corrected at its source and the distribution system and generating equipment benefitted equally. If pf-correcting equipment is placed in the power plant, solely generators are benefitted.

In Fig. 2, the capacitor is connected to the motor loads and is on the sys-

Table I—Power factors corresponding to angle of lag or lead between voltage and current

Angle	Power Factor	Angle	Power Factor	Angle	Power Factor
0	1.0000	31	0.8572	61	0.4848
1	0.9998	32	0.8481	62	0.4695
2	0.9994	33	0.8387	63	0.4540
3	0.9986	34	0.8290	64	0.4348
4	0.9976	35	0.8192	65	0.4226
5	0.9962	36	0.8090	66	0.4067
6	0.9945	37	0.7986	67	0.3907
7	0.9926	38	0.7880	68	0.3746
8	0.9903	39	0.7771	69	0.3584
9	0.9877	40	0.7660	70	0.3420
10	0.9848	41	0.7547	71	0.3256
11	0.9816	42	0.7431	72	0.3090
12	0.9782	43	0.7314	73	0.2924
13	0.9744	44	0.7193	74	0.2756
14	0.9703	45	0.7071	75	0.2588
15	0.9659	46	0.6947	76	0.2419
16	0.9613	47	0.6820	77	0.2250
17	0.9563	48	0.6691	78	0.2079
18	0.9511	49	0.6561	79	0.1908
19	0.9456	50	0.6428	80	0.1737
20	0.9396	51	0.6293	81	0.1564
21	0.9336	52	0.6157	82	0.1392
22	0.9272	53	0.6018	83	0.1219
23	0.9205	54	0.5878	84	0.1045
24	0.9136	55	0.5736	85	0.0872
25	0.9063	56	0.5592	86	0.0698
26	0.8988	57	0.5446	87	0.0523
27	0.8910	58	0.5299	88	0.0349
28	0.8830	59	0.5150	89	0.0174
29	0.8746	60	0.5000	90	0.0000
30	0.8660	60	0.5000	90	0.0000

Fig. 1—Capacitors connected to a group of motors for pf correction. Fig. 2—Capacitors correct pf of a single motor



tem only while the motor is in operation. If a motor is shut down and the capacitor is wanted on the system, then it is connected to the power side of the motor switch.

When it pays to correct pf is a question that can be answered only by proper consideration of several factors. When synchronous motors make up a large part of the load, it will be economical to maintain pf around unity. Under certain conditions a leading pf may be justified. Where correction is done with capacitors, it is frequently not economical to raise pf above 90% at the power house or substation busbars, but, under certain conditions, correction to nearly unity is justified.

How Much Correction?

To correct pf of a given load, the amount of corrective capacity necessary to produce desired results must be calculated. This is easily done by simple diagrams and power-factor values corresponding to out-of-phase angle of current and voltage, Table I. Unfamiliarity with alternating-current mathematics need not be a handicap, because the method given for solving power-factor problems involves only measuring length of lines with a scale and angles with a protractor.

The simplest case of pf correction is a capacitor used on a known load. Assume a load of 200 kw, and a 0.70 pf to be corrected to 0.90 with a capacitor. What size is required? Fig. 3 shows the solution of the problem. Before laying out the diagram, assume some scale, as for example 1 in. = 50 kw. Then a 4-in. line will represent 200 kw, which is the length that kw line *AB* would be made. In the table, a pf of 0.70 corresponds to a 45-deg angle. With *A* as a center, lay off a 45-deg angle above *AB* and draw a line at this angle with the kilowatt-load line. Then from *B*, draw a vertical line to form right-angle triangle *ABC*. In this triangle, line *AB* represents, to scale, the kilowatt-load, line *AC* the kilovolt-ampere load, and line *BC* the lagging reactive component of the load.

If side *AB* is 4 in. long to represent 200-kw load, side *AC* will be 5.7 in. long to represent a 50 × 5.7 = 285-kva load, and *BC* 4 in. long giving a reactive component of 50 × 4 = 200 kva.

Capacitor load is almost all leading reactive component and will directly replace part of the lagging reactive-component line *BC*. To determine capacitor size for correcting to 0.90 pf, find the angle corresponding to 0.90 in the table, which is about 25.5 deg. Lay off an angle of 25.5 deg above line *AB* and draw line *AD* at that angle to *AB*. Distances *CD* will scale approximately 2 in., making the capacitor size 50 × 2 = 100 kva. Line *AD* represents to scale the kva load after a 100-kva capacitor has been added. This is also equal to kilowatt load divided by pf, or 200 ÷ 0.90 = 222 kva.

Using PF Chart

This problem can be solved readily on the power-factor chart, Fig. 5, published by courtesy of General Electric Co. Values along the base of this chart represent kw load. Diagonal lines running up from the lower left-hand corner give pf and the arcs give kva loads read on the vertical left-hand scale. For example, a 600-kw load at 0.60 pf equals 600 ÷ 0.60 = 1000 kva. On the chart from 600 kw

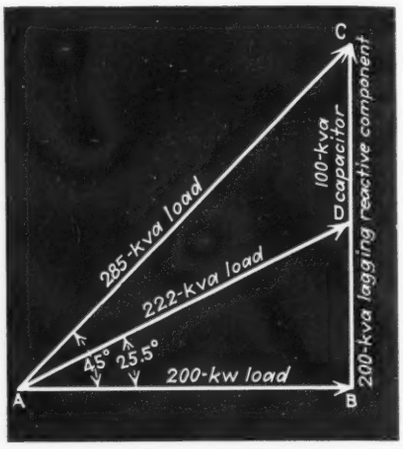


Fig. 3—Vector diagram showing 100-kva capacitor added to 285-kva, 0.70-pf load

follow vertically to intersect with the 0.60-pf line, then follow the curve to the vertical left-hand scale and find 1000 kva. Diagonal lines sloping up from the lower right-hand corner towards the left are for 0.80-pf synchronous motors.

To solve the first problem by the chart, find 200 kw at the bottom scale and follow vertical line to 0.70-pf line and then, along an arc to the vertical scale, read approximately 280-kva load. To find capacitor size for correcting pf to 0.90, drop down from intersection of 0.70-pf line with 200-kw line to intersection of 0.90-pf line. Vertical distance between the two pf lines, read on the left-hand vertical scale, is the capacitor size, or approximately 100 in this case.

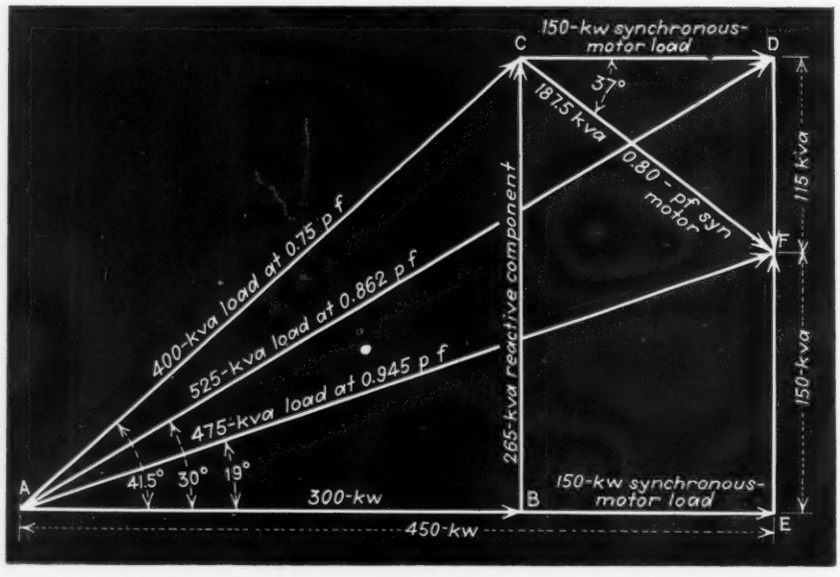
Synchronous Motors

When synchronous motors are used to correct power factor, method is similar. Assume a load of 300 kw and a 0.75 pf to which is added a unity-pf 150-kw synchronous motor. What will be the new pf? Construct the load diagram *ABC*, Fig. 4, as explained for Fig. 3, to a scale of 1 in. = 50 kw or kva. The 150-kw synchronous-motor unity-pf load will be 3 in. long, added to the kva load as line *CD* and to the kw load as an extension along line *AB* to *E*. A line connecting *A* and *D* represents to scale total kva load after adding the synchronous motor.

On a scale of 1 in. = 50 kva, line *AD* will equal 10.5 in., which represents a load of 10.5 × 50 = 525 kva. The new load pf equals 450 ÷ 525 = 0.867. In the pf table, 0.867 corresponds to an angle of 30 deg, which checks on the diagram. Adding 150-kw load increases total load from 400 to 525 kva, or 125 kva. This is 25 kva less than the load added, because pf was corrected from 0.75 to 0.867.

If an 0.80-pf motor were used, it would be added to Fig. 4 as triangle *CDF*. In the table, an 0.80 pf corre-

Fig. 4—Vector diagram showing 187.5-kva, 0.80-pf synchronous motor added to a 400-kva, 0.75-pf load



sponds to an angle of 37 deg. Draw line CF at an angle of 37 deg to line CD and this line represents to scale motor kva rating. This line on a diagram drawn to a scale of 1 in. = 50 kva will be 3.75 in. long and represent $3.75 \times 50 = 187.5$ kva, the rating of the motor.

Lagging-reactive component DF will be 3.3 in. long and represents 115 kva. Line AF will be about 9.5 in. long to represent the new load $9.5 \times 50 = 475$ kva. The new power factor is $450 \div 475 = 0.945$. In the table, a power factor of 0.945 corresponds to angle 19 deg, which checks with the angle between lines AE and AF, Fig. 4.

To solve these problems on the power-factor chart, Fig. 5, locate 300 kw at the base of the chart and follow vertically to the 0.75-pf line. Follow the arc to the left-hand vertical scale and read 400 kva. Project to the left from intersection of vertical 300 kw line with 0.75-pf line and read the reactive component, 265 kva, on the vertical scale.

To add the 150-kw unity-pf synchronous motor, from the intersection of 300-kw and 0.75-pf lines, run a line horizontal to the 450-kw vertical line. This intersection lies slightly right of 0.85-pf line at a point through which 0.866-pf line would pass. Following the arc through this intersection, read 525 kva on the vertical scale, the new kva load.

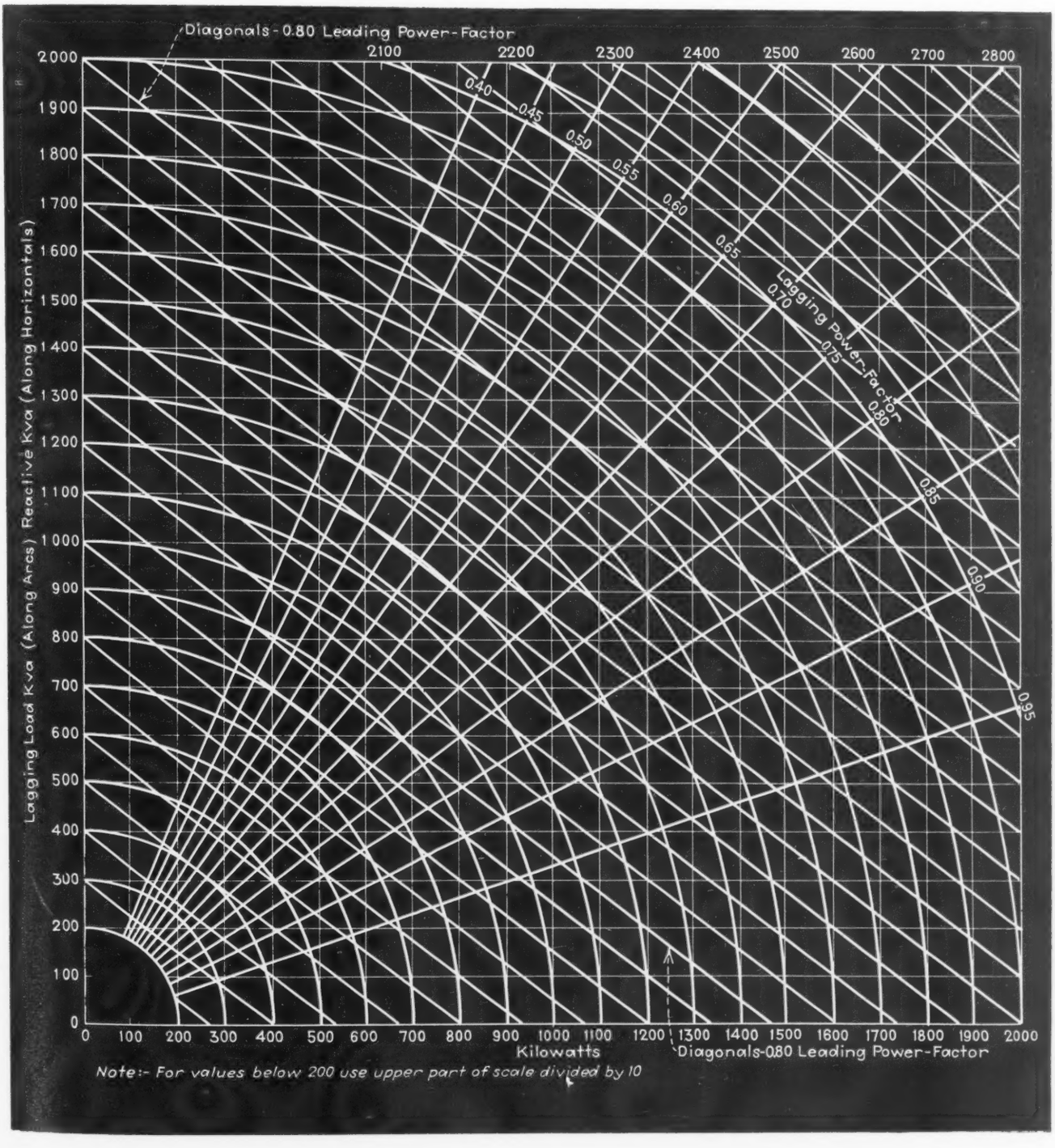
Add Motor Load

To add the 0.80-pf synchronous motor, from intersection of the 300-kw. and 0.75-pf lines, follow diagonal line to right parallel with the 0.80-pf line to intersect the 450-kw vertical line. This intersection will be practically on the 0.95-pf line and the arc through this point will terminate on the left-hand vertical scale at 475-kva, the load after adding the synchronous motor.

The 0.80-pf motor increased the motor load from 150 to 187.5 kva, or 37.5 kva. But in so doing, total load decreased 50 kva because pf is improved from about 0.87 to about 0.95. Starting from the original load of 400 kva, adding a load of 187.5 kva increased the total load only 75 kva to 475. The comparatively small increase in total load from adding the 0.80-pf motor indicates the economy of using such motors to correct pf where they can be applied.

Other pf problems can be solved by applying the principles used in Figs. 3 to 5. For loads smaller than 200 kw, multiply them by 10 and use the upper part of Fig. 5.

Fig. 5—Chart for direct solution of power-factor correction problems



MOTOR PROTECTION

■ MOTOR-CIRCUIT PROTECTION prevents damage to electrical equipment, driven machine, attendants, or to all three. Amount of protection depends on size and type of motor, circuit voltage, kind of load, and other factors.

For overload protection, fuses may be all that are necessary. Various types of thermal cutouts give protection by not disconnecting the motor until temperature approaches a dangerous limit. Overload and thermal relays in many forms are also used for motor protection.

Generally, no-voltage protection is required so that in case line voltage fails, the starter will return to *off* position. If starting is automatic, it may be dangerous to have the motor start again unless an attendant is present, in which case some form of lock-out relay or other device, that must be reset before the starter will function, is provided.

On ac motors, phase-failure and phase-rotation protection may be required. The former is to a degree provided by certain types of thermal-relay protection. The latter requires a special type of relay that remains closed as long as power lines are properly connected, but if a phase is reversed, the relay opens its contacts to prevent starting the motor in the wrong direction.

Code Requirements

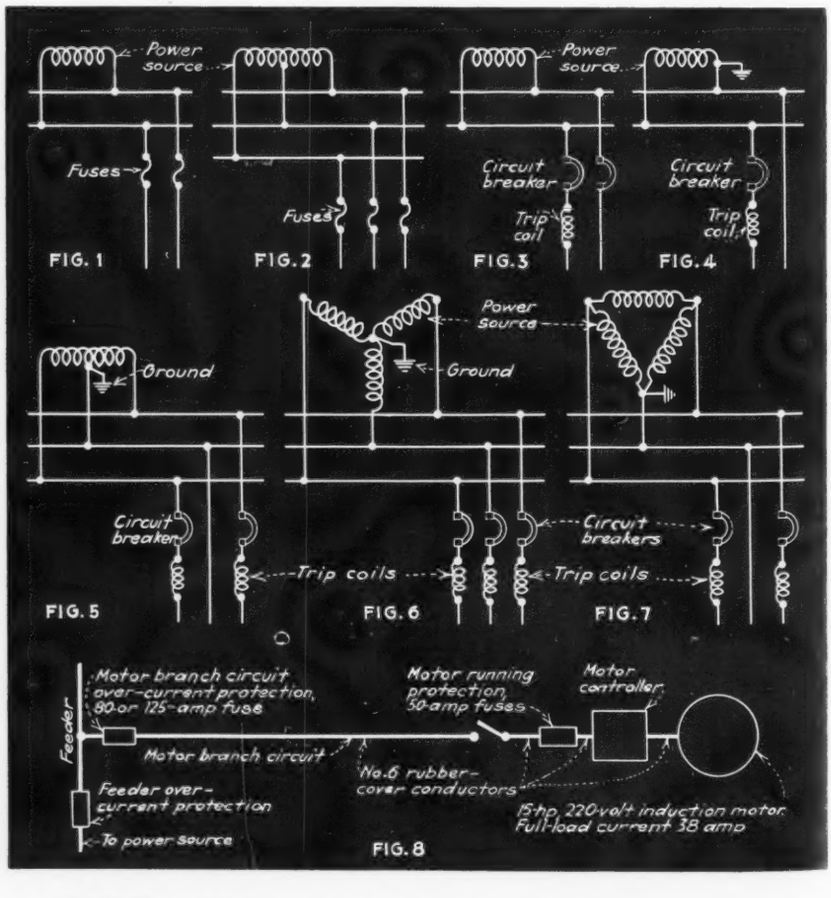
Kind of protection and how applied is largely determined by the National Electrical Code, which requires protection for ungrounded conductors. If fuses are used, then one must be placed in each ungrounded conductor, Figs. 1 and 2. With overload trip coils or relays, the protective device must open all ungrounded conductors, but on a 2-wire dc or ac circuit only one over-current unit is required, Fig. 3. On a 2-wire circuit, with one leg permanently grounded, the protective device need open only the ungrounded leg, and be tripped by an over-current unit in that leg, Fig. 4. A 3-wire system with grounded neutral must have both ungrounded conductors protected and an over-current unit in each leg, Fig. 5. An ungrounded 3-phase system, or one with a grounded neutral, requires protection in all three leads and if circuit breakers are used, a trip coil must be in each circuit leg, Fig. 6. If one circuit leg is permanently grounded, then protection is required in the two ungrounded conductors only, Fig. 7. These and other protection requirements are clearly set forth in the Code. Wherever circuit breakers are shown, fuses may be substituted.

On the facing page is reproduced the National Electric Code table of conductor sizes and over-current protection for motors. Column 1 gives full-load current of motors. For example, a 15-hp, 220-volt, 3-phase induction motor has a full-load rating of 38 amp. The wire size required for this motor is given in Columns 2 to 4. In most cases, a No. 6 rubber- or varnished-cambric-insulated wire will be used. This is not the size wire required by the Code for 38 amp, but motor full-load current plus 25%, or 48 amp. Motor branch-circuit wiring must be of a size that will carry 25% full-load current.

Column 5 gives maximum fuse rating at 50 amp, for running protection of the motor, which is the allowable current-carrying capacity of a rubber-insulated wire. If the motor is protected with a time-limit device, such as a circuit breaker, then it must be set to trip at not more than 47.5 amp, column 6. When the motor is started on full voltage or through a resistance or reactor, the branch-circuit protection, Fig. 8, can be 125-amp fuses, column 7, and 80-amp fuses if the motor is started on reduced voltage, column 8. For a dc or a wound-rotor ac motor, branch-circuit protection must not exceed 60 amp.

Feeder protection will depend upon the number and size of motors on it. The Code requires that a feeder supplying motors shall be provided with over-current protection not greater than the largest rating for the branch-circuit protection for any motor in the group plus the sum of the full-load currents of the other motors in the group. For example, assume that in Fig. 8 the feeder supplies two 10-hp motors, each with a full load current of 27 amp. Then, the feeder could be fused for $125 + 27 + 27 = 179$, say 175 amp. Special conditions are provided for in the Code, for which somewhat large branch-circuit and feeder fuses may be permitted.

Figs. 1 to 3—Protection of 2-wire and 3-wire ungrounded circuits. Figs. 4 and 5—Protection of 2-wire and 3-wire grounded circuits. Figs. 6 and 7—Protection of 3-phase grounded circuits. Fig. 8—Layout of motor branch circuit and protection



† Full-Load Current, Conductor Sizes and Over-Current Protection for Motors Permitted by National Electrical Code

Full-load current rating of motor	Minimum allowable size of copper wire, Am gage or cir mils			For Running Protection of Motors		Maximum Allowable Rating of Branch-Circuit Fuses		
				Max. rating of NEC fuses	Max. setting of time-limit protective device	Squirrel-cage & synchronous (full-voltage, reactor and resistor starting.) Single phase	Squirrel-cage & synchronous (auto-transformer starting.) High reactance squirrel-cage***	Wound rotor ac and dc
Amperes	Rubber	Vanished Cambric	Slow Burning	Amperes	Amperes	Amperes	Amperes	Amperes
Col. 1	2	3	4	5	6	7	8	9
1**	14	14	14	2*	1.25*	15	15	15
2**	14	14	14	3*	2.50*	15	15	15
3**	14	14	14	4*	3.75*	15	15	15
4**	14	14	14	6*	5.0 *	15	15	15
5**	14	14	14	8*	6.25*	15	15	15
6**	14	14	14	8*	7.50*	20	15	15
7	14	14	14	10*	8.75*	25	20	15
8	14	14	14	10*	10.0 *	25	20	15
9	14	14	14	12*	11.25*	30	25	15
10	14	14	14	15*	12.50*	30	25	15
11	14	14	14	15*	13.75*	35	30	20
12	14	14	14	15	15.00	40	30	20
13	12	14	14	20	16.25	40	35	20
14	12	14	14	20	17.50	45	35	25
15	12	12	14	20	18.75	45	40	25
16	12	12	14	20	20.00	50	40	25
17	10	12	12	25	21.25	60	45	30
18	10	12	12	25	22.50	60	45	30
19	10	12	12	25	23.75	60	50	30
20	10	12	12	25	25.0	60	50	30
22	8	10	10	30	27.50	70	60	35
24	8	10	10	30	30.00	80	60	40
26	8	8	8	35	32.50	80	70	40
28	8	8	8	35	35.00	90	70	45
30	6	8	8	40	37.50	90	70	45
32	6	8	8	40	40.00	100	70	50
34	6	6	8	45	42.50	110	70	60
36	6	6	8	45	45.00	110	80	60
38	6	6	8	50	47.50	125	80	60
40	6	6	8	50	50.00	125	80	60
42	5	6	6	50	52.50	125	90	70
44	5	6	6	60	55.0	125	90	70
46	4	6	6	60	57.50	150	100	70
48	4	6	6	60	60.0	150	100	80
50	4	5	6	60	62.50	150	100	80
52	4	5	6	70	65.0	175	110	80
54	4	4	6	70	67.50	175	110	90
56	4	4	6	70	70.00	175	120	90
58	3	4	5	70	72.50	175	120	90
60	3	4	5	80	75.00	200	120	90
62	3	4	5	80	77.50	200	125	100
64	3	4	5	80	80.00	200	150	100
66	2	4	4	80	82.50	200	150	100
68	2	4	4	90	85.00	225	150	110
70	2	3	4	90	87.50	225	150	110
72	2	3	4	90	90.00	225	150	110
74	1	3	3	9	92.50	225	150	125
76	1	3	3	100	95.00	250	175	125
78	1	2	3	100	97.50	250	175	125
80	1	2	3	100	100.00	250	175	125
82	0	2	2	110	102.50	250	175	125
84	0	2	2	110	105.00	250	175	150
86	0	2	2	110	107.50	300	175	150
88	0	2	2	110	110.00	300	200	150
90	0	1	2	110	112.50	300	200	150
92	0	1	2	125	115.00	300	200	150
94	0	1	2	125	117.50	300	200	150
96	0	1	2	125	120.00	300	200	150
98	0	0	2	125	122.50	300	200	150
100	0	0	2	125	125.00	300	200	150
105	00	0	1	150	131.5	350	225	175
110	00	0	1	150	137.5	350	225	175
115	00	0	1	150	144.0	350	250	175
120	00	0	1	150	150.0	400	250	200
125	000	00	0	175	156.5	400	250	200
130	000	00	0	175	162.5	400	300	200
135	000	00	0	175	169.0	450	300	225
140	000	00	0	175	175.0	450	300	225
145	200,000	000	0	200	181.5	450	300	225
150	200,000	000	0	200	187.5	450	300	225
155	200,000	000	0	200	194.0	500	350	250
160	200,000	000	0	200	200.0	500	350	250
165	0000	000	00	225	206.	500	350	250
170	0000	200,000	00	225	213.	500	350	300
175	0000	200,000	00	225	219.	600	350	300
180	0000	200,000	00	225	225.	600	400	300
185	250,000	200,000	000	250	231.	600	400	300
190	250,000	200,000	000	250	238.	600	400	300
195	250,000	0000	000	250	244.	600	400	300
200	250,000	0000	000	250	250.	600	400	300
210	300,000	0000	000	250	263.	—	450	350
220	300,000	250,000	000	300	275.	—	450	350
230	350,000	250,000	200,000	300	288.	—	500	350
240	350,000	250,000	200,000	300	300.	—	500	400
250	400,000	300,000	0000	300	313.	—	500	400
260	400,000	300,000	0000	350	325.	—	600	400
270	500,000	350,000	250,000	350	338.	—	600	450
280	500,000	350,000	250,000	350	350.	—	600	450
290	500,000	350,000	300,000	350	363.	—	600	450
300	500,000	400,000	300,000	400	375.	—	600	450
320	500,000	500,000	300,000	400	400.	—	—	500
340	600,000	500,000	350,000	450	425.	—	—	600
360	600,000	500,000	350,000	450	450.	—	—	600
380	700,000	500,000	400,000	500	475.	—	—	600
400	700,000	600,000	400,000	500	500.	—	—	600
420	800,000	600,000	500,000	600	525.	—	—	—
440	800,000	700,000	500,000	600	550.	—	—	—
460	900,000	700,000	500,000	600	575.	—	—	—
480	900,000	700,000	500,000	600	600.	—	—	—
500	1,000,000	800,000	600,000	—	625.	—	—	—
520	1,000,000	800,000	600,000	—	650.	—	—	—
540	1,100,000	900,000	600,000	—	675.	—	—	—
560	1,200,000	900,000	700,000	—	700.	—	—	—
580	1,200,000	1,000,000	700,000	—	725.	—	—	—
600	1,300,000	1,000,000	700,000	—	750.	—	—	—
625	1,400,000	1,000,000	800,000	—	782.	—	—	—

† *Also see Table 15, Chapter 9, 1937 Code.*

• *For running protection of motors of 1 hp or less, see section 4322, 1937 Code.*

** *For the grouping of small motors under the protection of a single set of fuses, see section 3448, 1937 Code.*

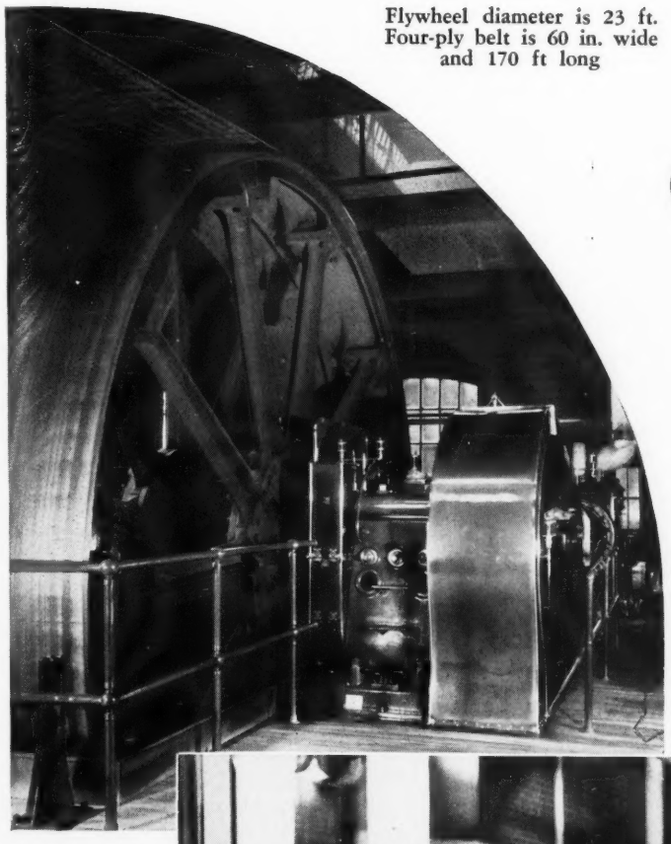
*** *High-reactance squirrel-cage motors are those designed to limit the starting current by means of deep-slot secondaries or double-wound secondaries and are generally started on full voltage.*

Commercial Copper Wires and Metal Conduits

Their Properties and Some Requirements Governing Installation

B & S Gage No.	Area in Circular Mils = (Dia. in Mils)²	Diameter in Mils = √Circ. Mils (Solid)	Resistance Ohms at 68 F: Per 1000 Ft	Resistance Ohms at 68 F: Per Mile	Weight Bare, Lb.: Per 1000 Ft	Weight Bare, Lb.: Per Mile	Typical Cable Stranding §: Strands: No. of Strands	Typical Cable Stranding §: Strands: Dia. in Mils.	Typical Cable Stranding §: Outside Dia., Bare, In.	Required Size of Conduit, 2-Wire and 3-Wire Systems †: No. of Conductors in One Conduit: 1	2	3	4	5	6	7	8	9	Distance Between Supports in Vertical Risers, Ft	Rubber Insulation (A): Allowable Carrying Capacity, Amperes	Rubber Insulation (A): Volts Drop per 1000 Ft at Rated Current	Rubber Insulation (A): 600 Volts: One Braid: Approx. Over-all Dia., In.	Rubber Insulation (A): 600 Volts: One Braid: Approx. Weight per 1000 Ft Complete, Lb	Rubber Insulation (A): 600 Volts: Two Braids: Approx. Over-all Dia., In.	Rubber Insulation (A): 600 Volts: Two Braids: Approx. Weight per 1000 Ft Complete, Lb	Varnished-Cloth Insulation. B ‡: Allowable Carrying Capacity, Amperes	Varnished-Cloth Insulation. B ‡: Volts Drop per 1000 Ft at Rated Current	Varnished-Cloth Insulation. B ‡: 600 Volts: One Braid: Approx. Over-all Dia., In.	Varnished-Cloth Insulation. B ‡: 600 Volts: One Braid: Approx. Weight per 1000 Ft Complete, Lb	Varnished-Cloth Insulation. B ‡: 600 Volts: Two Braids: Approx. Over-all Dia., In.	Varnished-Cloth Insulation. B ‡: 600 Volts: Two Braids: Approx. Weight per 1000 Ft Complete, Lb	Other Insulation C: Allowable Carrying Capacity, Amperes	Other Insulation C: Volts Drop per 1000 Ft at Rated Current	B & S Gage No.
	Circular Mils									Minimum Size of Conduit, Elec. Trade, Size, In.																						Circ. Mils
....	2,000,000	1,414	0.0052	0.0274	6,100	32,200	127	125.5	1.632	3	5	6	...	...	...	...	...	...	35	1,050	5.5	2.02	6,950	2.14	7,050	1,260	6.6	2.02	6,850	2.14	6,950	1,670	8.7	2,000,00
....	1,900,000	1,378	0.0055	0.0290	5,796	30,600	127	122.3	1.590	3	5	6	...	...	...	...	...	...	35	1,010	5.6	1.98	6,650	2.10	6,750	1,210	6.7	1.98	6,450	2.10	6,550	1,610	8.9	1,900,00
....	1,800,000	1,342	0.0058	0.0306	5,490	29,000	127	119.1	1.548	3	5	6	6	...	...	...	...	...	35	970	5.6	1.93	6,300	2.05	6,400	1,160	6.7	1.93	6,100	2.05	6,200	1,550	9.0	1,800,00
....	1,700,000	1,304	0.0062	0.0327	5,186	27,400	91	136.7	1.504	3	5	5	6	...	...	...	...	...	35	930	5.8	1.88	5,950	2.00	6,050	1,120	6.9	1.88	5,700	2.00	5,800	1,490	9.2	1,700,00
....	1,600,000	1,265	0.0065	0.0343	4,880	25,800	91	132.6	1.459	2½	5	5	6	...	...	...	...	...	35	890	5.8	1.84	5,650	1.96	5,750	1,070	7.0	1.84	5,400	1.96	5,500	1,430	9.3	1,600,00
....	1,500,000	1,225	0.0070	0.0369	4,576	24,200	91	128.4	1.412	2½	4½	5	6	...	...	...	...	...	35	850	6.0	1.79	5,300	1.91	5,400	1,020	7.1	1.79	5,000	1.91	5,100	1,360	9.5	1,500,00
....	1,400,000	1,183	0.0075	0.0396	4,270	22,500	91	124.0	1.364	2½	4½	5	6	...	...	...	...	...	35	810	6.1	1.74	5,000	1.86	5,100	970	7.3	1.74	4,700	1.86	4,800	1,290	9.7	1,400,00
....	1,300,000	1,140	0.0084	0.0443	3,963	20,900	91	119.5	1.315	2½	4½	5	6	6	...	...	...	...	35	770	6.5	1.68	4,650	1.80	4,750	920	7.7	1.68	4,400	1.80	4,500	1,220	10.2	1,300,00
....	1,200,000	1,095	0.0088	0.0464	3,660	19,300	91	114.8	1.263	2½	4½	4½	6	6	...	...	...	...	35	730	6.4	1.63	4,300	1.74	4,400	880	7.7	1.63	4,050	1.75	4,150	1,150	10.1	1,200,00
....	1,100,000	1,048	0.0095	0.0501	3,356	17,700	91	109.9	1.209	2½	4	4½	6	6	...	...	...	...	35	690	6.6	1.57	4,000	1.69	4,100	830	7.9	1.57	3,750	1.69	3,850	1,080	10.3	1,100,00
....	1,000,000	1,000	0.0105	0.0555	3,050	16,100	61	128.0	1.152	2	4	4	5	6	6	...	...	...	35	650	6.8	1.50	3,650	1.62	3,750	780	8.2	1.50	3,400	1.62	3,500	1,000	10.5	1,000,00
....	950,000	974.7	0.0111	0.0586	2,898	15,300	61	124.8	1.122	2	4	4	5	6	6	6	...	...	35	625	6.9	1.48	3,450	1.60	3,550	750	8.3	1.48	3,250	1.60	3,350	960	10.7	950,00
....	900,000	948.7	0.0117	0.0617	2,745	14,500	61	121.5	1.093	2	3½	4	4½	5	6	6	...	...	35	600	7.0	1.46	3,300	1.58	3,400	720	8.4	1.46	3,100	1.58	3,200	920	10.8	900,00
....	850,000	922.0	0.0124	0.0655	2,593	13,700	61	118.0	1.062	2	3½	4	4½	5	6	6	...	...	35	575	7.1	1.42	3,150	1.54	3,250	690	8.6	1.42	2,950	1.54	3,050	880	10.9	850,00
....	800,000	894.4	0.0131	0.0691	2,440	12,900	61	114.5	1.031	2	3½	4	4½	5	6	6	6	...	35	550	7.2	1.38	3,000	1.50	3,050	660	8.6	1.38	2,800	1.50	2,850	840	11.0	800,00
....	750,000	866.0	0.0140	0.0739	2,288	12,100	61	110.9	0.997	2	3½	3½	4½	5	6	6	6	...	40	525	7.4	1.35	2,800	1.47	2,850	630	8.8	1.35	2,650	1.47	2,700	800	11.2	750,00
....	700,000	836.7	0.0150	0.0792	2,135	11,300	61	107.1	0.964	2	3½	3½	4½	5	5	6	6	...	40	500	7.5	1.32	2,650	1.44	2,700	600	9.0	1.32	2,450	1.44	2,500	760	11.4	700,00
....	650,000	806.2	0.0168	0.0886	1,983	10,500	61	103.2	0.929	2	3½	3½	4	4½	5	6	6	6	40	475	8.0	1.28	2,500	1.40	2,550	570	9.6	1.28	2,300	1.40	2,350	720	12.1	650,00
....	600,000	774.6	0.0175	0.0923	1,830	9,660	61	99.2	0.892	2	3	3½	4	4½	5	6	6	6	40	450	7.9	1.24	2,300	1.36	2,350	540	9.5	1.24	2,100	1.36	2,150	680	11.9	600,00
....	550,000	741.6	0.0191	0.101	1,678	8,860	61	95.0	0.854	1½	3	3½	4	4½	5	5	6	6	40	425	8.1	1.19	2,100	1.31	2,150	510	9.7	1.19	1,950	1.31	2,000	640	12.2	550,00
....	500,000	707.1	0.0210	0.111	1,525	8,050	37	116.2	0.814	1½	3	3	3½	4	4½	5	5	6	50	400	8.4	1.13	1,900	1.25	1,950	480	10.1	1.13	1,750	1.25	1,800	600	12.6	500,00
....	450,000	670.8	0.0234	0.124	1,373	7,250	37	110.3	0.772	1½	3	3	3½	4	4½	5	6		50	365	8.5	1.08	1,700	1.20	1,750	435	10.2	1.08	1,550	1.20	1,600	550	12.9	450,00
....	400,000	632.5	0.0263	0.139	1,220	6,440	37	103.9	0.727	1½	3	3	3½	4	4	4½	5	5	50	325	8.5	1.02	1,500	1.14	1,550	390	10.3	1.02	1,400	1.14	1,450	500	13.2	400,00
....	350,000	591.6	0.0300	0.158	1,068	5,640	37	97.2	0.680	1½	2½	3	3½	4	4	4½	4½	5	60	300	9.0	0.97	1,350	1.08	1,400	360	10.8	0.97	1,250	1.08	1,300	450	13.5	350,00
....	300,000	547.7	0.0350	0.185	915	4,830	37	90.0	0.630	1½	2½	3	3	3½	3½	4	4½	4½	60	275	9.6	0.92	1,180	1.01	1,230	330	11.6	0.92	1,080	1.01	1,130	400	14.0	300,00
....	250,000	500.0	0.0420	0.222	762	4,020	37	82.1	0.575	1½	2½	2½	3	3	3½	3½	4	4½	60	250	10.5	0.85	980	0.94	1,030	300	12.6	0.85	900	0.94	950	350	14.7	250,00
0000	211,600	460.0	0.0497	0.262	645	3,400	19	105.5	0.528	1½	2	2½	2½	3	3	3½	3½	4	80	225	11.2	0.77	810	0.86	850	270	13.4	0.77	750	0.86	790	325	16.2	0000 B & S
000	167,800	409.6	0.0625	0.330	513	2,710	19	94.1	0.471	1	2	2	2½	3	3	3	3½	3½	80	175	10.9	0.71	680	0.80	720	210	13.1	0.71	630	0.80	670	275	17.2	000
00	133,100	364.8	0.0789	0.416	406	2,140	19	83.7	0.419	1	2	2	2½	2½	3	3	3	3½	80	150	11.8	0.67	550	0.75	590	180	14.2	0.67	500	0.75	540	225	17.8	00
0	105,500	324.9	0.0995	0.525	322	1,700	19	74.6	0.373	1	1½	2	2	2½	2½	3	3	3	100	125	12.4	0.62	450	0.70	490	150	14.9	0.62	410	0.70	450	200	19.9	0
1	83,690	289.3	0.1258	0.663	255	1,346	19	66.3	0.332	1	1½	1½	2	2	2½	2½	3	3	100	100	12.6	0.57	370	0.62	390	120	15.1	0.57	330	0.62	350	150	18.9	1
2	66,370	257.6	0.1579	0.833	203	1,072	7	97.5	0.293	1	1½	1½	1½	2	2	2	2½	2½	100	90	14.2	0.50	290	0.54	305	110	17.4	0.50	260	0.54	275	125	19.7	2
3	52,630	229.4	0.2004	1.059	160	845	7	86.6	0.260	1	1¼	1½	1½	2	2	2	2	2½	100	80	16.0	0.47	245	0.52	260	95	19.0	0.47	225	0.52	240	100	20.0	3
4	41,740	204.3	0.2525	1.333	127	671	7	77.1	0.231	1	1¼	1¼	1½	2	2	2	2	2	100	70	17.7	0.44	200	0.49	215	85	21.5	0.44	185	0.49	200	90	22.7	4
5	33,100	181.9	0.3130	1.653	100	528	7	68.8	0.206	1	1¼	1¼	1½	1½	2	2	2	2	100	55	17.2	0.41	170	0.46	180	65	20.3	0.41	155	0.46	165	80	25.0	5
6	26,250	162.0	0.394	2.080	79.46	419.5	7	61.2	0.184	1	1	1¼	1¼	1½	1½	2	2	2	100	50	19.7	0.39	140	0.43	150	60	23.6	0.39	125	0.43	135	70	27.6	6
8	16,510	128.5	0.641	3.388	49.98	263.9	7	48.4	0.145	¾	¾	1	1	1	1¼	1¼	1¼	1¼	100	35	22.4	0.32	90	0.36	100	40	25.6	.....	.....	.....	.....	50	32.0	8
10	10,380	101.9	1.010	5.333	31.43	166.0	7	38.6	0.116	¾	¾	1	1	1	1	1¼	1¼	1¼	100	25	25.3	0.27	63	0.30	69	30	30.3	.....	.....	.....	.....	30	30.3	10
12	6,530	80.8	1.601	8.453	19.77	104.4	7	30.6	0.092	¾	¾	¾	1	1	1	1	1¼	1¼	100	20	32.0	0.24	47	0.28	53	25	40.0	.....	.....	.....	.....	25	40.0	12
14	4,107	64.1	2.565	13.54	12.43	65.6	7	24.2	0.073	¾	¾	¾	¾	1	1	1	1	1	100	15	38.5	0.22	35	0.26	42	18	46.2	.....	.....	.....	.....	20	51.3	14
*16	2,583	50.8	4.040	21.33	7.82	41.3	7	19.3	0.058	...	...	...	...	...	...	...	...	...	.....	6	.....	0.16	18	.....	.....	.....	.....	.....	.....	.....	.....	10	.....	16
*18	1,624	40.3	6.567	34.67	4.92	26.0	7	15.1	0.045	...	...	...	...	...	...	...	...	...	.....	3	.....	0.14	13	.....	.....	.....	.....	.....	.....	.....	.....	5	.....	18

* Wires smaller than No. 14 B & S gage are not permitted, except for fixture work and flexible cords. † For sizes not greater than No. 10 B & S gage, one more conductor than indicated in above table may be installed in th specified conduit, provided the conduit is not longer than 30 ft. and has not more than the equivalent of two quarter bends from outlet to outlet, the bends at the outlets not being counted. Except in the case of stage pocket an border circuits the same conduit must not contain more than four 2-wire or three 3-wire circuits of the same system, except by special permission, and must never contain circuits of different systems. ‡ Varnished-cloth-insulated wire smaller than No. 6 B & S gage may be used only by special permission from the Inspection Department. § For conduit work the National Electric Code requires wires of No. 6 B & S gage or larger to be stranded so as to make ther flexible. While the exact stranding used by different manufacturers varies somewhat, the typical stranding given in the table is generally representative of common practice. Because of the twist in the strands, the weight of a strande conductor is greater than of equivalent solid wire, and the resistance is also greater, the increase being generally considered as about 2% for both weight and resistance.

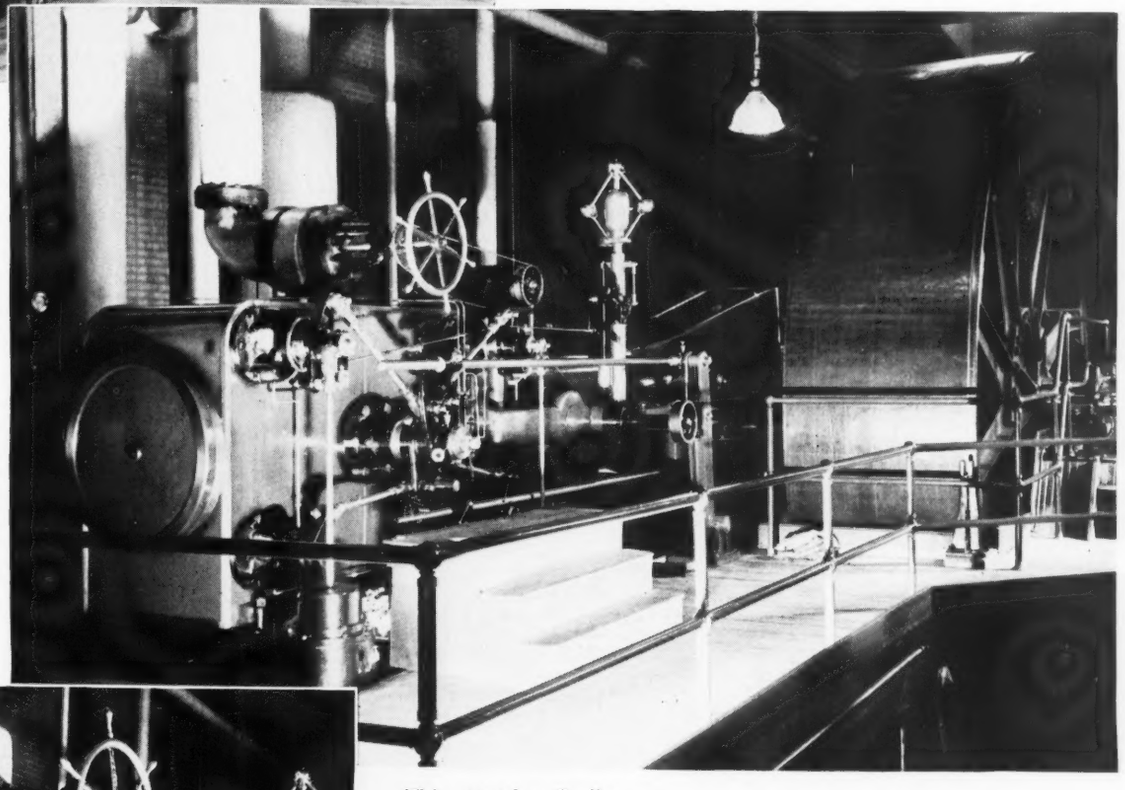


Flywheel diameter is 23 ft. Four-ply belt is 60 in. wide and 170 ft long

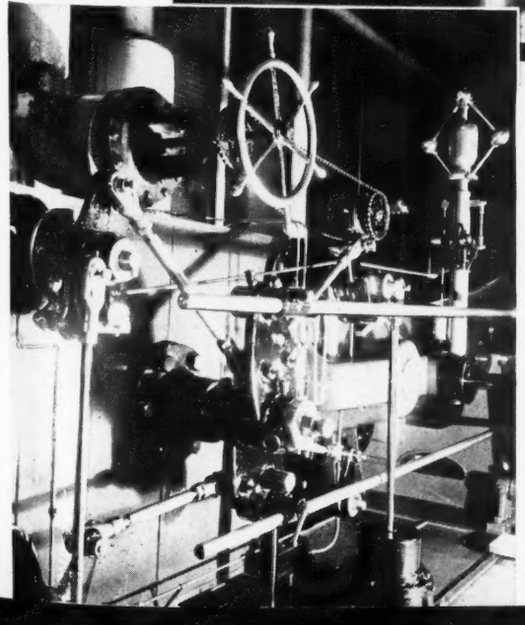
Old Timer

LARGELY DISPLACED today by faster moving turbines, uniflows and diesels, the old-time Corliss still holds the affection of practical power men everywhere. Its valve mechanism was out in the open. Parts moved slow enough to be watched, and you didn't need a blue print to see how and why everything worked. No more dependable power unit has ever been produced.

Many of the old Corliss engines are still running; for example, this 1000-hp Watts-Campbell engine installed in 1893 at the Philadelphia plant of Nicholson File Co. With 30-in. bore and 60-in. stroke, she turns at 60 rpm. Flywheel, cast in 10 sections, bolted together, is 23 ft in diameter.



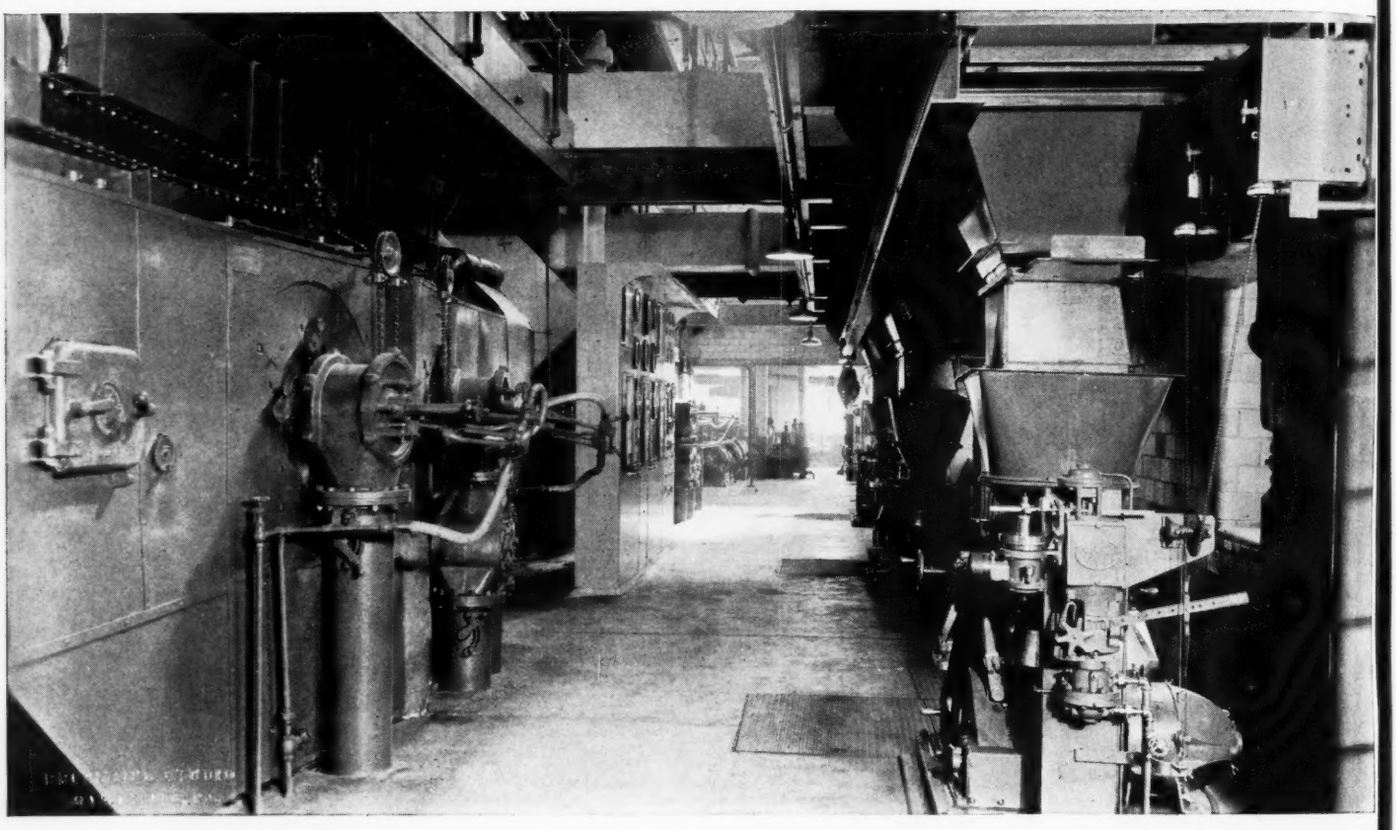
This 1000-hp Corliss is still running sweetly today after 45 years service. Note original belt still in perfect condition



Brass and steel polished like this are the engineer's universal mark of respect for one of the world's most beautiful mechanisms—the Corliss valve gear

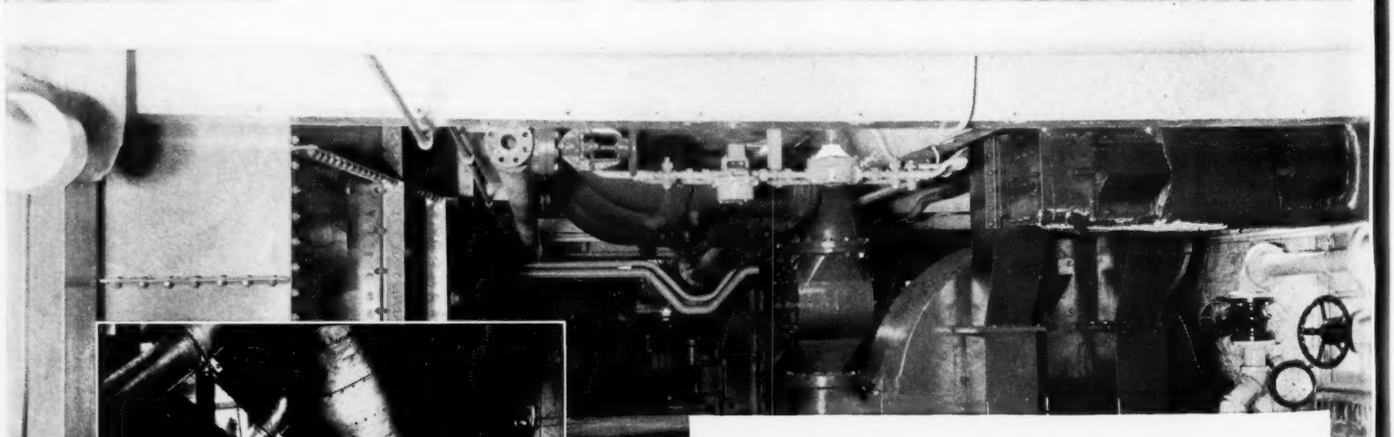
The 4-ply belt, 60 in. wide and 170 ft long, is a hardy symbol of durability; it has been driving the mill machinery for 45 years. Allowing 2500 hours operation per average year, total mileage is around 5,500,000, enough to carry the belt around the world 220 times. In spite of this globe trotting, the leather is still in perfect condition.

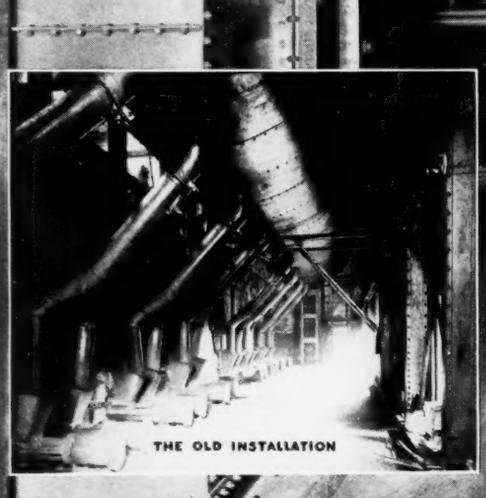
Out in The Firing Aisle about Boiler Equipment!



FIRING AISLE AT W. VA. PULP & PAPER CO., WILLIAMSBURG, PA.
2-71,500 lbs/hr. Riley Steam Generating Units

Below—Basement showing Installation of Riley Pulverizers





THE OLD INSTALLATION

Do you receive The FIRING AISLE?

Riley Stoker Corporation regularly publishes an eight-page pamphlet called the **FIRING AISLE**. This pamphlet illustrates and gives engineering data about many of the recent installations of Riley Steam Generating Units. Copies will be gladly sent you free upon request.

is the place to find out

To purchase wisely be sure to visit a number of Riley installations before purchasing Boiler Equipment

Out in the firing aisle is the only place where you can definitely find out about the performance of boiler equipment. There you can see the equipment performing under actual operating conditions, can investigate past performance and maintenance records, can talk man to man with the men who live with the equipment and know what it can do.

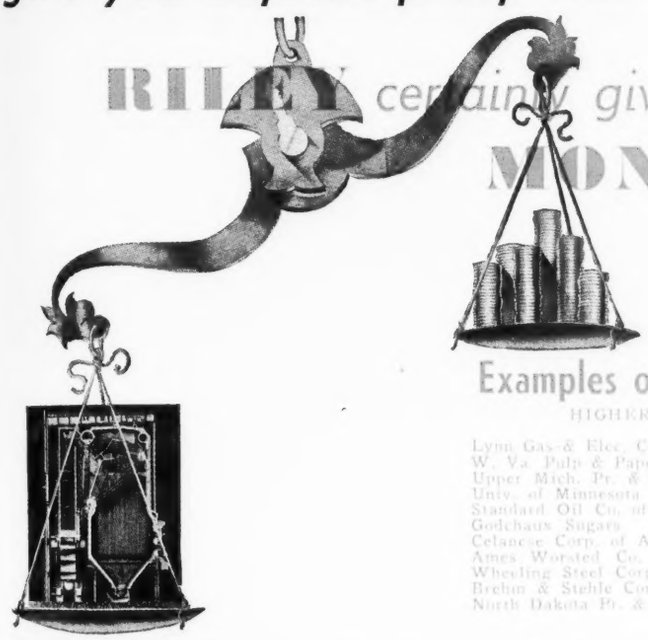
The purchase of new boiler equipment is a serious matter to an engineer because the character of his purchase reflects his ability as an engineer. Don't overlook the fact also that you have to live with your purchase for many years to come. Isn't it only sensible therefore to thoroughly investigate equipment actually performing in the field before making a purchase.

Any manufacturer whose equipment can stand up well under such close scrutiny, encourages thorough investigations. Riley strongly recommends such investigations! An inspection of a number of recent Riley installations will prove to you what an excellent job Riley is doing; will convince you of the many plus values in Riley Equipment; and will

give you definite proof that

RILEY certainly gives You Your

MONEY'S WORTH



Examples of your money's worth in Riley Equipment

HIGHER CAPACITY	Guaranteed	Actual
Lynn Gas & Elec. Co.	205,000	260,000
W. Va. Pulp & Paper Co.	72,500	100,000
Upper Mich. Pr. & Lt. Co.	90,000	120,000
Univ. of Minnesota	100,000	125,000
Standard Oil Co. of Calif.	125,000	146,000
Godchaux Sugars	100,000	125,000
Celanese Corp. of Amer.	150,000	175,000
Ames Worsted Co.	70,000	85,000
Wheeling Steel Corp.	100,000	120,000
Brehm & Stehle Corp.	30,000	50,000
North Dakota Pr. & Lt. Co.	50,000	70,000

HIGHER EFFICIENCY	Guaranteed	Actual
Wheeling Steel Corp.	84.1	85.7%
Newport Electric	75.8	86.6%
Howard State Hospital	76	87.3%
W. Va. Pulp & Paper Co.	83.2	84 %
Godchaux Sugars	82	83.5%
Lewiston Bleachery	81.2	82.9%
Savannah Sugar Refining	75.6	86.2%
Fort Bend Utilities	82.3	83.8%
Lynn Gas & Electric	86.1	87.7%
Kalamazoo Veg. Parchment	85.2	86.5%
Upper Mich. Pr. & Lt. Co.	85	86.3%

These Companies recently thoroughly investigated and then purchased Riley Equipment

Northern Paper Mills, Green Bay Wis.
Houston Power & Light Co., Houston, Texas
Allis Chalmers Mfg. Co., Milwaukee, Wis.
City of Columbus, Ohio
Boro of Lansdale, Pa.
Western Cartridge Co., E. Alton, Ill.
Winchester Repeating Arms, New Haven, Conn.
Barrett Co., Philadelphia, Pa.
Humble Oil & Refining Co., Baytown, Texas
Humble Oil & Refining Co., Ingleside, Texas
City of Detroit Lakes, Minn.
Great Lakes Steel Corp., Detroit, Mich.
Port Huron Sulphite & Paper Co., Port Huron, Mich.
Natrona Power & Light Co., Natrona, Pa.
Otter Tail Power Co., Wahpeton, N. D.
Hartford City Paper Co., Hartford City, Ind.
Celanese Corp. of America, Cumberland, Md.
Hellwig Silk Dyeing Co., Philadelphia, Pa.
Libby Owens Ford Glass Co., Rossford, Ohio
Central Ohio Power & Light Co., Bluffton, Ohio
General Aniline Works, Rensselaer, N. Y.
American Brass Co., Kenosha, Wis.
Godchaux Sugars, Reserve, La.
Moore Steam Turbine Co., Wellsville, N. Y.
Riverside Metal Corp., Riverside, N. J.
W. Va. Pulp & Paper Co., Luke, Md.
W. Va. Pulp & Paper Co., Covington, Va.
Newport Electric Co., Newport, R. I.
Publicker Commercial Alcohol Co., Philadelphia, Pa.
Burroughs Adding Machine Co., Detroit, Mich.
Wheeling Steel Corp., Portsmouth, Ohio
Central Illinois Light Co., Peoria, Ill.
MacAndrews & Forbes Co., Camden, N. J.
University of Maryland, College Park, Md.
North Dakota Power & Light Co., Beulah, N. D.
Fort Bend Utilities Co., Sugarland, Texas

TRADE MARK Rx REGISTERED

RILEY

STOKER CORPORATION, WORCESTER, MASS.

Boston New York Philadelphia Pittsburgh Buffalo Cleveland Detroit Tacoma Baltimore Milwaukee Denver
St. Louis Cincinnati Houston Chicago St. Paul Kansas City Los Angeles Atlanta Memphis New Orleans

COMPLETE STEAM GENERATING UNITS

BOILERS • PULVERIZERS • BURNERS • STOKERS • SUPERHEATERS • AIR HEATERS
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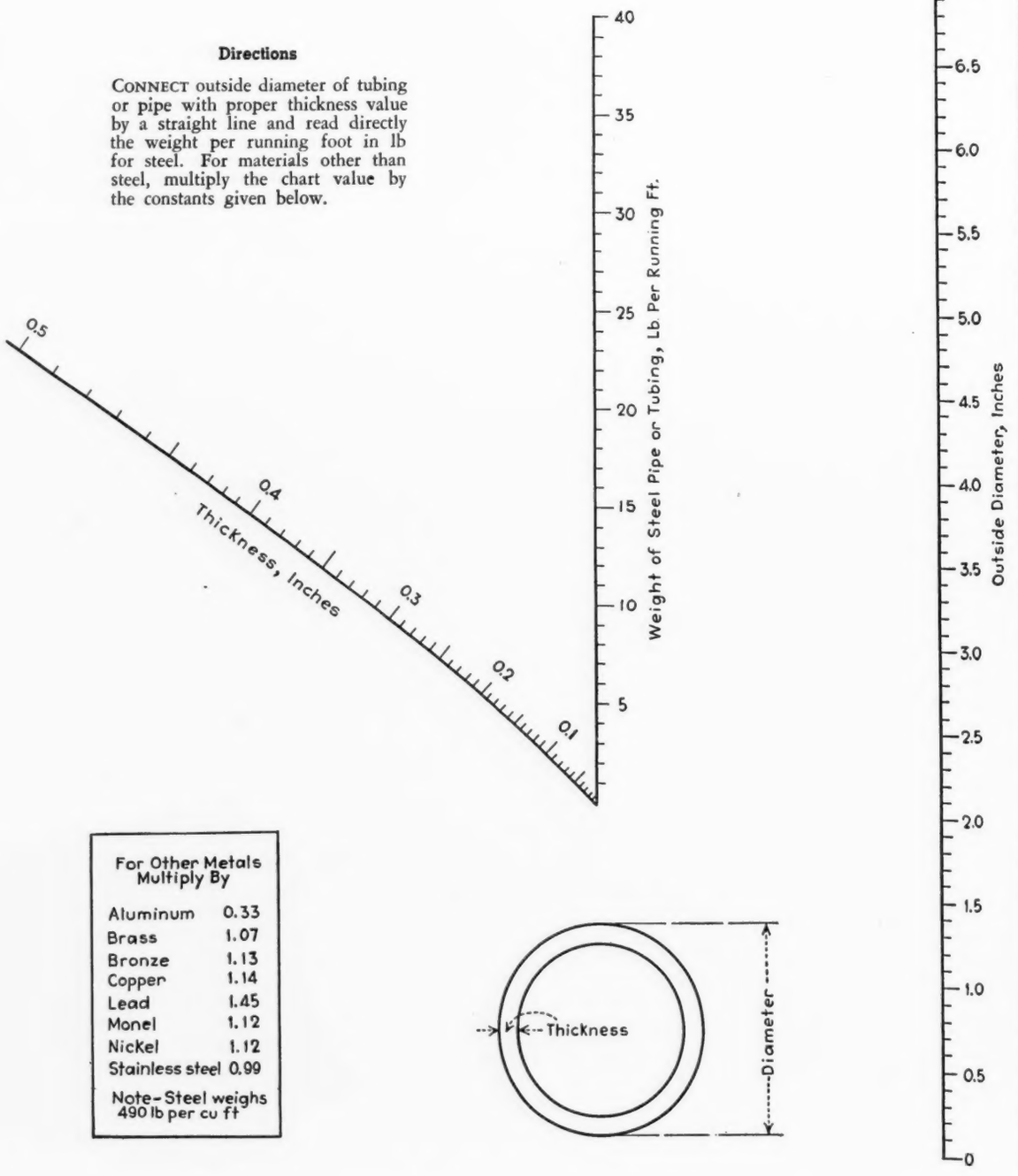
Weight of Metal Tubing

Number 68

Directions

CONNECT outside diameter of tubing or pipe with proper thickness value by a straight line and read directly the weight per running foot in lb for steel. For materials other than steel, multiply the chart value by the constants given below.



For Other Metals Multiply By	
Aluminum	0.33
Brass	1.07
Bronze	1.13
Copper	1.14
Lead	1.45
Monel	1.12
Nickel	1.12
Stainless steel	0.99

Note-Steel weighs 490 lb per cu ft

S A Tucker

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Putting the Heat on Valve Materials

Hardness study reveals in graphs and tables how body, bonnet, bolt, stud and nut materials will stand up at temperatures up to 1100 F

By M G BOLINGER* and WM HEILIG†
The Wm Powell Co, Cincinnati, Ohio

THERE have been repeated requests for hardness values of valve materials at elevated temperatures. In view of the scarcity of published data, we have undertaken a study of structural materials now in use. Much helpful criticism and a review of past methods of testing were obtained from an article by Dr. Oscar E Hardner in "National Metals Handbook" (1936). Pertinent references are given by Dr. Hardner, but not for the materials we were considering.

By adding an extension arm to carry a special sintered carbide ball, a standard Brinell machine was modified to heat, electrically, specimen and ball to the same temperature. The furnace, Fig. 1, was designed and built with an insulated pillar through the bottom, upon which the specimen rests. The extension arm and support are so proportioned that the surface of the specimen to be tested, and the ball, are approximately in the center of the furnace.

Temperature is regulated by a Tagliabue indicating potentiometer which controls current supply through two tap transformers. Fig. 1 is a general view of the modified Brinell machine and control.

No special machining is needed to prepare the test specimen; usual specimens are taken from bar stock, cast or forged, approximately 1 in. in diameter. A small hole, drilled at an angle of 45 deg from contact face of the specimen, carries the thermocouple. Length of specimen is $\frac{3}{4}$ in.

In the usual test procedure, the ball is not placed immediately in contact with the face of the specimen. This delay avoids excessive pressure on the test-machine head, caused by expansion of the specimen as it comes up to temperature. When the specimen is slightly below test temperature, the ball is brought in contact, and both are then raised to test temperature together. Specimen and ball are held at temperature for 15 minutes before test load is applied. Load is held on the specimen for 30 seconds. A Thwing "Treasure Chest" checks temperature. The controller on the furnace allows a maximum variation of approximately 1.5 F. Tests to date indicate that results may be readily duplicated.

Hardness values for 23 different steels and alloys, at elevated temperatures, are given in Table I. Fig. 2 indicates the trend in hardness of body and bonnet materials with increasing temperatures. Fig. 3 indicates the variation in hardness with heat treatment for one particular steel. The dotted curve beside No. 4b shows hardness value after holding for 1 hour and 15 minutes at the test temperature.

Hardness values of typical trim materials are shown in Fig. 4, and

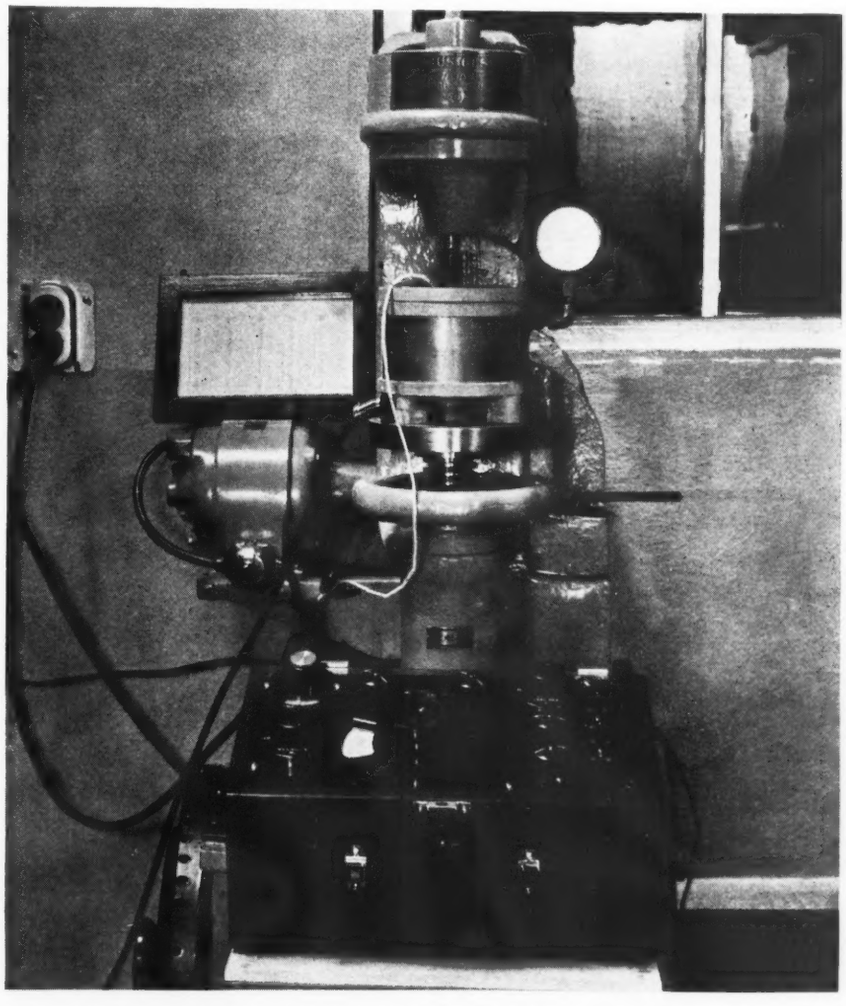


Fig. 1—Brinell machine modified for high-temperature testing

* *Metallurgist.*
† *Head of Research and Development.*

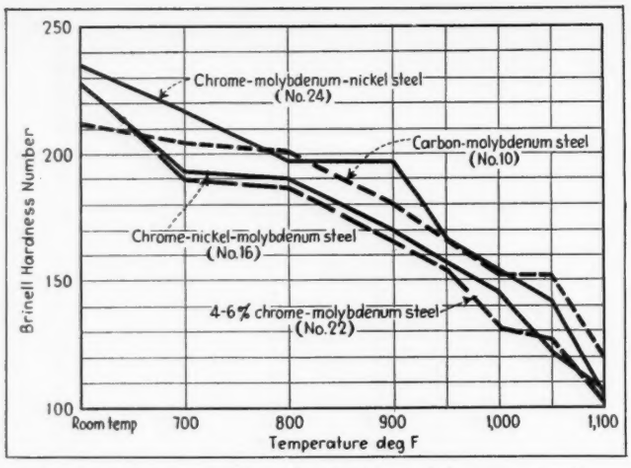


Fig. 2—Average values for body and bonnet steels

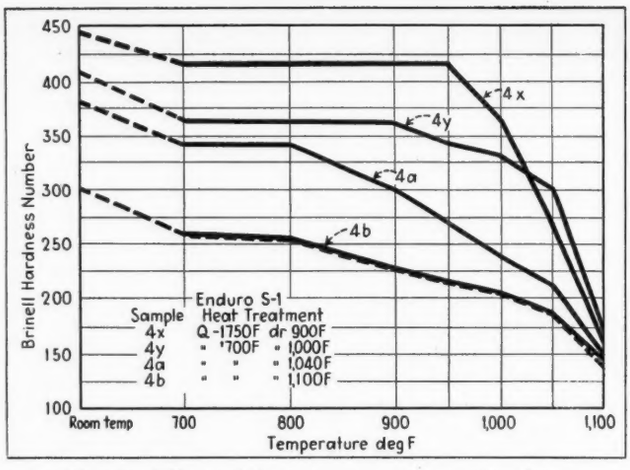


Fig. 3—Effect of draw temperature on hardness

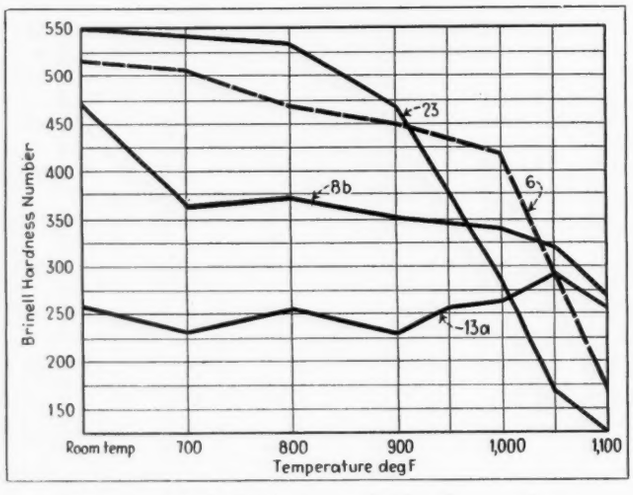


Fig. 4—Typical trim material hardness values

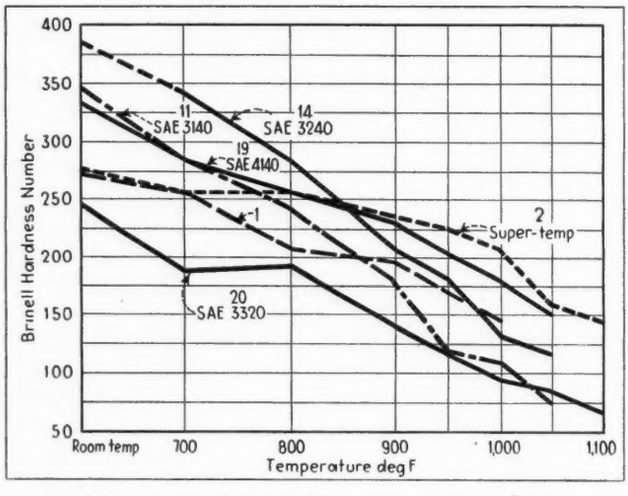


Fig. 5—Steel for bolts, studs, nuts and pins

values of steels used for bolts, studs etc, in Fig. 5. Hardness values and chemical analyses for all steels are listed in Table I. Heat treatments are given in Table II, and Table III shows the per cent drop in hardness at 900 F and 1100 F.

Of the many steels and alloys tested, probably the most outstanding was the non-ferrous alloy, Nos. 13a and 13b. This is a copper-nickel-silicon-iron alloy known as S-Monel. While not of exceptionally high hardness at room temperatures, it stays fairly hard in service up to 1100 F. On one

Table I—Hardness at Temperatures

Steel No.	Type No.	Room temp.	700	800	900	950	1000	1050	1100	C	Mn	Si	Ni	Cr	Mo	W	Co	Fe
8a	12	444	321	262	269	.....	223	.....	241	.....	.....	....	....	33.00	.....	10.00	57.00	.....
8b	12	472	363	370	352	.....	341	321	269	.....	.....	.....	.....	33.00	.....	10.00	57.00	.....
7	325	156	126	128	123	.....	121	118	121	.17	.52	1.27	20.43	7.48	.....	.....	.....	.....
3x	416	296	269	287	289	.....	262	.....	156	.10	.55	.27	.....	14.18	.....	.....	.....	.....
3y	416	276	255	258	248	.....	235	.....	149	.10	.55	.27	.....	14.18	.....	.....	.....	.....
4b	410	302	260	255	229	.....	207	187	143	.13	.50	.42	.....	12.70	.....	.....	.....	.....
4a	410	379	341	341	300	.....	239	212	148	.13	.50	.42	.....	12.70	.....	.....	.....	.....
4x	410	444	415	415	415	415	363	269	163	.13	.50	.42	.....	12.70	.....	.....	.....	.....
4y	410	408	363	363	360	341	331	302	170	.13	.50	.42	.....	12.70	.....	.....	.....	.....
5a	410	310	302	311	277	.....	217	201	140	.38	.40	.24	.....	13.95	.....	.....	.....	.....
5b	410	388	341	363	341	.....	229	167	134	.38	.40	.24	.....	13.95	.....	.....	.....	.....
15	410	270	241	229	207	174	116	128	.....	.12	.....	.....	.....	12.50	.....	.....	.....	.....
12a	410	322	293	302	293	217	197	126	118	.16	.18	.08	.....	12.70	.....	.....	Cu	.....
13a	.....	255	229	255	229	255	262	293*	255	.16	.75	3.13	62.55	.....	.....	.....	29.92	3.43
13b	.....	296	269	262	273	.....	255	266	229	.16	.75	3.13	62.55	.....	.....	.....	29.92	3.43
14	SAE 3240	385	341	285	207	179	131	116	.....	.52	.55	.23	1.52	1.16	.....	.....	.....	.....
20	SAE 3320	245	187	192	140	.....	93.7	85.5	67	.22	.50	.....	3.55	1.60	.....	.....	.....	.....
24	03	235	217	197	197	169	149	143	109	.26	.56	.42	1.55	.60	.28	.....	.....	.....
24a	03	235	217	197	197	163	156	138	101	.26	.56	.42	1.55	.60	.28	.....	.....	.....
16	07	229	187	183	170	.....	140	131	105	.29	.64	.42	2.10	.78	.38	.....	.....	.....
16a	07	228	197	197	170	.....	149	114	107	.29	.64	.42	2.10	.78	.38	.....	.....	.....
22	04	230	197	185	159	159	120	126	88	.18	.47	.41	.....	4.70	.42	.....	.....	.....
22a	04	230	179	187	170	149	143	126	116	.18	.47	.41	.....	4.70	.42	.....	.....	.....
10	02	229	207	207	197	.....	170	170	140	.33	.63	.17	.33	1.29	.58	.....	.....	.....
10a	02	205	187	197	152	.....	146	149	114	.29	.66	.38	.....	.....	.45	.....	.....	.....
10b	02	242	217	197	187	.....	140	126	99.2	.29	.66	.38	.....	.....	.45	.....	.....	.....
2	.....	277	255	255	235	223	207	159	143	.40	.55	.19	.....	.53	.57	1.06	.....	.....
1	.....	275	255	208	198	.....	143	.....	.....	.52	.....	.....	.....	.....	.....	.....	.....	.....
11	SAE 3140	347	285	241	179	118	109	74	.....	.35	.80	.23	1.29	.55	.....	.....	.....	.....
19	SAE 4140	333	285	255	229	201	179	159	149	.40	.77	.16	.....	.98	.20	.....	.....	.....
6	420	514	506	470	450	.....	415	.....	170	.38	.44	.28	.....	14.90	.....	.....	.....	.....
12b	420	388	375	353	353	.....	170	163	121	.35	.31	.09	.....	13.23	.....	.....	.....	.....
17	420	470	444	444	425	.....	212	146	103	.30	.....	.....	.....	13.00	.....	.....	.....	.....
23	440	550	514	534	469	.....	285	170	126	1.04	.46	.23	.20	16.76	.....	.....	Co	.....
9a	6	383	269	285	273	.....	229	.....	.....	.....	.....	.....	.....	29.00	.....	6.00	65.00	.....
9b	6	404	290	277	269	.....	240	234	285	.....	.....	.....	.....	29.00	.....	6.00	65.00	.....

* Held 12 hrs. at temperature.

C — Carbon Cr — Chromium **Fe — Iron** Mo — Molybdenum Si — Silicon
Co — Cobalt Cu — Copper **Mn — Manganese** Ni — Nickel W—Tungsten

Table II—Heat Treatment

Steel No.	Type	Quenched from	Drawn for 1 Hr	Hardness
3x....	416	1750	900	296
3y....	416	1750	975	276
4b....	410	1700	1100	302
4a....	410	1700	1040	379
4x....	410	1750	900	444
4y....	410	1700	1000	408
5a....	410 [1]	....	....	310
5b....	410 [2]	1750	900	388
15.....	410 [3]	1700	1100	270
4b....	410	1700	1100	302
13b....	....	....	1110 [4]	296
14.....	SAE3240	1500	950	385
20.....	SAE3320	1475	1100	245
11.....	SAE3140	1500	900	347
19.....	SAE4140	1575	1100	333
6.....	420	1850	800	514
17.....	420	1900	850	470
23.....	440	1850	850	550
22a....	04	1700	1250*	230
16a....	07	1700	1200*	229
10a-b..	02	1650	1200*	220
24a-b..	03	1650	1200*	217

particular test, we maintained 1050 F for 20 hours; when tested at the end of that period, this material gave a Brinell Hardness No. of 302.

The only other alloys capable of maintaining such high hardness values at temperatures of 1050 and 1100 F were the Stellites. Considering its ease of fabrication, this new alloy (S-Monel) shows great promise as valve-trim material.

As a result of these tests, a better appreciation of hardness at high temperature of the many materials used in valves has been obtained.

[1] Forged material as received.
[2] Annealed No. 5 and air cooled from 1400 F then hardened.
[3] Cast material.
[4] Held at temperature 24 hour.
* Air cooled.

Table III—Per cent Drop in Hardness

Type	At 900 F.	At 1100 F.
12	30.0%	44.0%
325	21.0	22.0
416	6.0	46.0
410	14.0	56.0
SAE 3240	46.0	74.0
SAE 3320	42.0	72.0
SAE 3140	48.0	82.0
SAE 4140	31.0	55.0
03	16.0	55.0
07	25.0	54.0
04	28.0	56.0
02	24.0	52.0
Super temp	15.0	48.0
Nut stock	28.0	....
Non-Ferrous	9.0	11.0

What Happens to Sodium Sulphite?

Field tests contradict laboratory reports showing decomposition of sodium sulphite at boiler temperatures

REPORTING the ASME Annual Meeting, Mid-December *Power* (page 809) carried the following brief summary of the conclusions reached in a paper by Taft, Johnstone and Straub: "W O Taft and Profs H F Johnstone and F G Straub, University of Illinois, reviewed their experiments on the decomposition of sodium-sulphite solutions at high temperatures. The sulphite is now widely used to prevent corrosion by removing the last traces of dissolved oxygen. Four-hour tests, made in steel bombs, indicated that decomposition to sodium sulphide, sulphate and thiosulphate begins to take place at some temperature between 530 and 560 F."

Power's attention has since been called to other experiments which seem to indicate that the results obtained in actual operation of boilers are at variance with the laboratory tests reported by Straub and his associates. To put this other side of the picture on the record for the information of power engineers, the following comments are summarized from an extensive report, by R M Hitchens and J W Purssell, of a joint research project of the Monsanto Chemical Co and the Boston Edison Co of Boston, Mass. The length of the paper and its highly technical nature permit here only a brief summary of high spots and conclusions:

Tests of both boiler water and steam were made on two boiler units—a 1400-lb boiler (No. 7) of the Boston Edison Co at Edgar Station, Weymouth, Mass., and the 675-lb boiler in the St. Louis Plant of the Monsanto Chemical Co. For brevity, the two boilers will hereafter be referred to as the "1400-lb boiler" and the "675-lb boiler."

Two different samples, tested by two methods, showed no measurable sodium sulphide, in the boiler water of the 1400-lb boiler. Hitchens and Purssell concluded that the sulphide content of this water is less than 0.02 ppm. Less sensitive tests on the 675-lb (operating pressure) boiler showed a sulphide content of the boiler water less than 0.4 ppm (S), the limit of sensitivity.

The steam produced by both boilers was sampled at superheater inlet and outlet, corresponding temperatures being 577 F and 725 F for the 1400-lb boiler and 497 F and 740 F for the 675-lb unit. In the 675-lb boiler (equipped with modern steam washers), entirely negative results, less than 0.01 ppm (S), were obtained even with 130 ppm of sodium sulphite in the boiler water. The authors state that this precludes the possibility, not only of mechanical carryover, but also of sulphur dioxide being distilled from the water. This in turn proves that there is no hydrolysis of sodium sulphite to SO_2 and NaOH.

Data on steam from the 1400-lb boiler, with sodium-sulphite concentrations of 0 to 175 ppm and full boiler loads, showed some carryover, rising to a maximum of 0.2 ppm (S) with 175 ppm sodium sulphite in the boiler water. Disappearance of this sulphite at low loads indicated there was no hydrolysis of sodium sulphite even at this temperature.

More significant were the results obtained with the boiler water, which results are at variance with the laboratory tests of Professor Straub and his associates. According to their laboratory observations, sodium-sulphite solution undergoes rapid auto-decomposition to sodium sulphide and sulphate at 579 F, the reaction progressing halfway in 90 minutes. If the same thing happened in the 1400-lb boiler (577 F), it would be necessary to feed an enormous amount of sodium sulphite to maintain any appreciable residual. Likewise, dose feeding would show a high initial concentration which would drop 50% in 90 minutes, 75% in three hours, etc. Actually, the boiler water contained sulphite even after a whole week of boiler operation without sulphite additions. Making all possible allowances, the authors say that the extent of auto-decomposition in 44 hours cannot possibly be over 20%, whereas the University of Illinois experimentors found 20% auto-decomposition in 30 minutes at the same temperature.

Recently, one of the writers of the report here summarized observed the application of sodium sulphite to a 1790-lb pressure boiler, fed continuously with 2.5 lb per day of anhydrous technical sodium sulphite. This proved sufficient to maintain 30 ppm of sodium sulphite in the boiler water with a steam output of 2,400,000 lb per day. The over-all consumption of sulphite was, therefore, only one lb per million lb of steam generated.

(*Continued on page* 126)

Readers' Problems

Questions *for Our Readers*

Soot Blowers Blanket Fire

Question 1

IN OUR BOILER *the soot blowers blanket the fire to the extent of causing smoke, gas, and often flame, to emerge from the fire door instead of going out the stack. We are using a Murray 4120-sq ft horizontal tubular boiler, which is fired from the rear due to its peculiar location in the plant. The breeching leading from the stack is approximately 4 x 6 ft and 50 ft long. The stack is 125 ft high. The boiler is fired with an Iowa 1-in. screening, on a Hoffman Fyrite stoker.*

We have attempted to assist furnace draft and force the gas into the breeching by opening two of the fixed blowers that point parallel with the flow of gas, to boost the draft during the time of soot-blower operation. At times we feel this does some good, but at other times it seems to have no effect whatever. An interesting though somewhat questionable effect is that wind direction and velocity create additional blanketing at times. A brisk wind blowing parallel to the breeching and toward the boiler makes this blanketing much worse than normal. We also note that in the summer time, at high noon when the sun shines directly into the stack, the blanketing is markedly increased. Can any POWER *readers suggest a solution to this problem?*—JMC.

Water in Lube Oil

Question 2

WE HAVE *a mechanical lubricator oiling the cylinder walls of each of two 8 x 8-in. ammonia compressors, and have recently identified these two lubricators as the source of water in the lubricating oil. Due care has always been taken to fill with pure oil, but on draining the lubricators on several occasions, it was noticed that great quantities of small water globules were suspended in the oil. A day or two after refilling, the same condition would reappear.*

It is difficult to account for the water and my only guess is that it condenses on the lid of the lubricators or working parts during cool weather. Or is it possible that due to the presence of traces of ammonia gas in the oil, it absorbs minute particles of water from the air, in quantities that are not visible to the eye. There seem to be no other explanations, for all oil is carefully scrutinized before a light, prior to filling. We are using Texas Co's "Capella Oil."

Is there a simple, inexpensive way of filtering out this finely divided moisture without resorting to costly centrifugal purifiers? We have tried passing the oil through cotton cloth, and through rayon, but with only partial success, for a portion of the water persists in coming through with the oil.—AFD

Suitable answers from readers will be paid for if space is available for publication.

Commutator Black Spots

Answers to February Question 1

The Question

WE OPERATE *three 100-kw, 3-wire, compound-wound, 220-volt dc generators. One of them developed a burned commutator which we trued up. After 6 months, the burned spots are developing again. The spots are three bars wide, tapering off to nothing in about six more bars.*

There are six sets of brushes on the machine and the burned spots occur at three places spaced equally around the commutator. Can some POWER *readers tell me what the cause of this trouble may be?*—GCC.

Many Possible Causes

COMMUTATOR blackening may be due to a number of causes. Sometimes the trouble is a result of one, but more often is a combination of two or three. Some common causes of commutator blackening are: (1) Sparking of the brushes, (2) brushes with insufficient abrasive action, (3) too low brush pressure, (4) brushes sticking in their holders, (5) commutators have high mica, (6) load on the unit is such that current surges through the commutator and brushes, and (7) high-resistance joints at the commutator bars or in the armature coils.

We had trouble similar to that mentioned by GCC on one of our generators, and felt sure that it was due either to an open-circuited coil or to high-resistance joints at the armature coils or commutator segments. We checked the armature coils and commutator and found every circuit uniform. We then replaced electro-graphitic brushes with carbon-graphitic ones and increased brush pressure to 2.5 lb per sq in. This eliminated the trouble.

On another unit, inspection disclosed poorly madeup soldered joints at the commutator segments. The solder had only made a surface contact. Although from visual inspection the joints appeared satisfactory, when they were unsoldered, only 1/10 of the joint surface was found tinned to the commutator segments. Correcting these joints eliminated bar burning.

Tenafly, N. J. K B HOFFMAN

Defective Field Coils May Cause the Trouble

A BAD field coil may be the seat of GCC's difficulty. If part of the field is shorted out, the armature will generate less voltage under that field pole and cause circulating currents in the armature coils. A voltmeter reading across each shunt-field coil will check the trouble.

Any unbalance of the series fields will cause the same trouble, but to a lesser degree and is not as likely to occur. Polarity of the fields should alternate, north and south. Shunt and series fields should be checked to see that they agree in polarity.

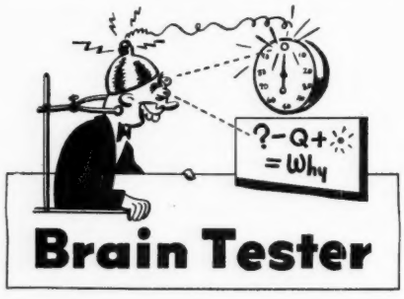
Damaged insulation is often responsible for black spots on the commutator. A chafed wire, which caused an intermittent short circuit, kept me guessing for quite a while on a similar trouble.

Leesville, S. C. F E BRODIE

Armature at Fault

THAT the commutator burning is not general indicates that the fault lies in the armature itself and not in any of the non-rotating parts. Burning of the bars occurs from sparking, which may be caused by roughness of commutator, vibration, a short-circuited coil, an open-circulated coil, poor design or poor construction.

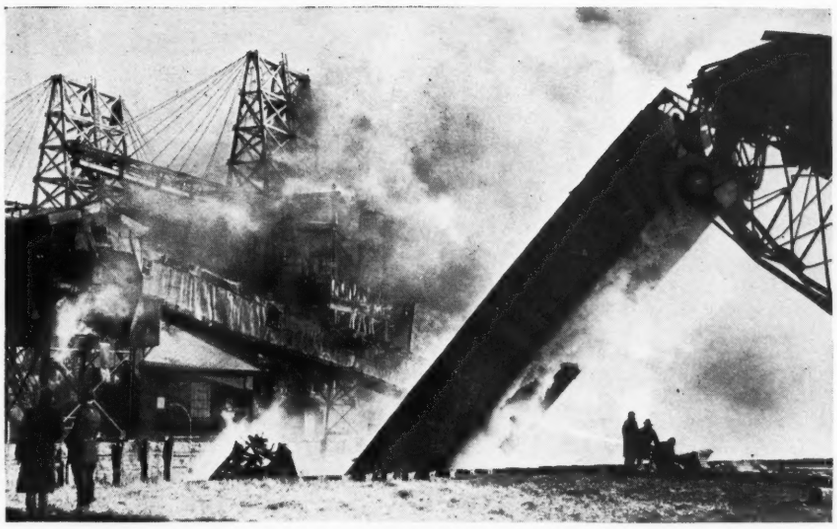
In my opinion, the trouble with this machine lies in poor construction. For dc machines of this size, it is usually necessary to form each lamination of the armature iron from two or more stampings. In the assembly of these



Sharpen your wits on this little problem, then check your answer with the one given on page 124:

BILL WINS A BET

BILL had a tank full of lube oil and three empty cans, capacity as follows: red can, 7 gal.; blue can, 5 gal.; and yellow can, 4 gal. With this equipment he bet he could measure out any whole number of gallons from 1 to 10 inclusive. He won his bet. How?



LYNN UTILITY HAS NARROW ESCAPE

Uninterrupted service according to best power traditions was maintained at the generating plant of the Lynn (Mass.) Gas & Electric Co on Feb 10, when a fire causing damage estimated at $750,000 destroyed a large part of the coal wharf, tower and conveying system. A vigorous battle and wind shift saved the plant itself. Peak load on the station, about 17,000 kw on the day of the fire, was served in part by interconnection with New England Power Co system, and the generating plant of General Electric Co's Lynn works was also made available

stampings to form the completed armature, the assembly may not be truly round. This inaccurate construction would cause the air gap under any particular pole to vary with the armature position.

Suppose that commutating poles are carrying the proper current for perfect commutation of the majority of the armature coils. When one of the armature "lumps" comes along, the air gap is shortened, thus increasing the amount of flux available for commutation, causing the brushes to spark and burn the commutator. The armature defect would similarly affect neighboring coils as the minimum gap is approached, thus causing less extensive burns either side of the worst burn. The fact that it takes 6 months for the trouble to show up indicates that this condition, if it is the cause, is not very pronounced and that variation in air gap may not be very evident.

A similar effect may be obtained if the armature laminations are made of 120-deg stampings assembled to form three straight lines across the surface of the armature. This condition would cause non-uniform armature construction and burning at three 120-deg points, affecting adjacent bars. Normal armature construction avoids this defect.

New York, N. Y. V P RADER

Recommends Softer Brushes

I HAVE overcome trouble similar to that mentioned by GCC by using softer brushes that have some graphite in them. The generator has run steadily for the past two years around 90% loaded and has not given any further trouble nor have the black spots returned on the commutator. My feeling is that GCC can eliminate his trouble in the same way.

Denver, Col. PAUL C HANSEN

Selecting Paint

Answers to February Question 2

The Question

OUR PLANT *has a great many windows which are steel sash. In the winter months, so much steam is given off in the plant by warming pans that the windowpanes and sash are continually wet. We have had to repaint frequently due to rust on the sash. We use ordinary black paint and have not previously tried to get off the old paint which is now peeling and cracking badly. This year we are going to scrape off the old paint and start over again.*

Can POWER *readers suggest the best method of getting the old paint off and whether a coat of red lead and then ordinary black paint is the best that can be done, or is there some special paint that will last longer?*—ECM.

Three Possible Solutions

FOR CONDITIONS such as ECM is encountering, there are three kinds of paint which have given good results: (1) Asphalt-base paints using aluminum powder as coloring matter. The base gives protection, the aluminum powder a pleasing appearance. (2) Rubber-base paints, in various colors. These have proved successful in laundries and kitchens where steamy conditions exist, and can even be applied when the surface is wet. (3) Paints with a synthetic rosin finish, available in colors.

Lakewood, Ohio J P SIMONS

Use Prepared Primer and Paint

AFTER SCRAPING all old paint off steel sash, a primer should be applied. This can be "Tecter," a Pittsburgh Plate Glass Co product, and should be used according to instructions. The single priming coat should dry for at least one day. The second coat should be Pittsburgh's "Florhide" enamel, also applied according to directions. This paint is waterproof and will withstand weather changes. Three coats are not necessary, but will result in a better looking and more serviceable job.

Huntington, Ind. P H BRIDGE

Suggests Prime Coat of Aluminum Paint

HEAVY CONDENSATION from a battery of Bruce-MacBeth engines with "bath-tub" type of heads, settling on roof structures and steel window frames, gave us the same problem ECM mentions. Our experience was that water of condensation did not soften the paint on these surfaces, but rather attacked at the line of metal-to-metal or metal-to-glass contact, working under the preservative, causing minute flakes of rust to break the hold of the paint on the steel. More and more water was admitted, until the paint flaked off in scaly blisters.

Several repaintings with usual factory interior paints convinced us we were on the wrong track, so we scraped the frames, washed them with a good cleaning solution, and applied a prime coat of fine-mesh aluminum paint. After this coat had thoroughly dried and on a warm dry day when the engines were down, window frames and roof members were painted in the desired color with a good grade enamel. Since changing to aluminum paint as a primer, in place of conventional red lead, the steel-work coating stands up as long as the wall and roof paint and formation of rust blisters has been practically eliminated.

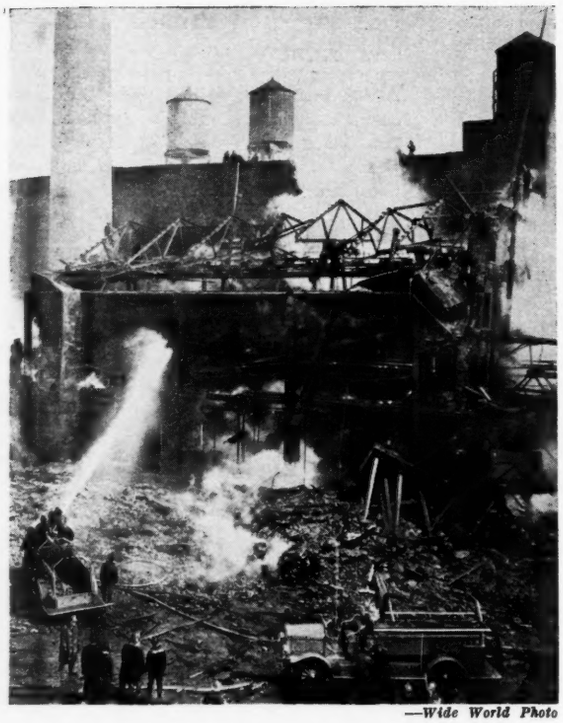
Kilgore, Texas C C LYNDE

Cut Down Moisture Effect

IN ANSWERING ECM's question, there are three steps. In the first place, steam lines and equipment should be thoroughly checked and tightened to reduce steam leakage to a minimum. Secondly, it is quite possible that steam from the pans can be drawn off in a duct system and exhausted outside. *Power's* recent air-conditioning section (February, 1938) and representatives of air-conditioning companies should be consulted with this in mind.

Finally, remove old paint by scraping and sandpapering, and when the sash is perfectly clean and dry, and on a bright sunny day, apply a priming coat of red lead and two coats of aluminum paint. Allow time between coats for drying, of course. Do no painting on damp cloudy days and when there is a free steam in

(*Continued on page 122*)



—*Wide World Photo*

DUST AND DESTRUCTION

Dust is not only a nuisance but a real source of danger. Here's what happens when an explosive mixture of fuel-dust and air meets up with a spark — Horton Pilsener Brewery, New York, N. Y.

Power Lines

Midwest Power Conference In Chicago, April 13-15

The Midwest Power Conference, sponsored by Armour Institute of Technology in cooperation with Iowa State College, Purdue University, State University of Iowa, University of Illinois, University of Michigan and University of Wisconsin, will meet in Chicago, Ill., April 13-15, with headquarters at the LaSalle Hotel.

The program for the 3-day meeting has been arranged to cover many subjects. P W Swain, editor of Power, will open the session with an address on "Social Significance of Power Progress." A companion paper on "Trends of Research in the Power Industry" by C F Hirshfeld, chief of research of Detroit Edison Co, will report on probable technical progress for the near future.

A group of technical conferences will follow the opening session. Wednesday afternoon, April 13, will be devoted to three conferences on (1) Fuels, (2) Trends in Electric Power Equipment, and (3) Locomotive Power Units. Conferences on Thursday morning, April 14, will include (1) Developments in Stationary Power Plants, (2) Power Measurements, and (3) Valuation of Power Plants. Thursday afternoon will be devoted to study of (1) Metals, (2) Problems in the Operation of Power Plants, and (3) Hydro Power.

A special program arranged for Friday, April 15, includes an inspection trip to Armour Tech where two papers on "Heat Energy Costs or Btu Auditing" and "Power Requirements for Residential Air Conditioning" will be presented. This will be followed by an inspection of the high-pressure laboratory, where Dr T C Coulter has reached the record pressure of 1,500,000 lb per sq in. After luncheon on the campus, conference members will go to the Carnegie-Illinois plant to inspect a new power installation and steel-manufacturing equipment.

Second Contract Let for Grand Coulee

Contract for the completion of the high dam at Grand Coulee, on the Columbia River, was awarded January 28 to Interior Construction Co, Oakland, Calif, at $34,442,240. The successful bidder is a newly-organized combination of well-known contractors including the builders of Boulder Dam and the lower section of Grand Coulee, just completed.

The contract involves manufacture and placement of about 5,250,000 cu yd of concrete, which will bring the dam to its full height of 553 ft, and the placing of 160,000,000 lb of reinforcing steel, 10,000,000 lb of piping, 50,000,000 lb of gates and operating devices, 24,000,000 lb of trash-rack metal, and 16,000,000 lb of penstock.

Commenting on the award of the contract, John C Page, Commissioner of Reclamation, said, "This marks the next step in the construction of the greatest structure ever built by man. It contains three times more concrete than does Boulder Dam."

Fuel-Dust Explosion Wrecks Power Plant

With a blast felt miles away, a mixture of air and fuel-dust exploded in the boiler room of the Horton Pilsener Brewery, New York, N. Y., at 1:20 PM, March 4, killing three and injuring 17. The fire that followed, and fumes from broken ammonia lines, accounted for many of the injuries. The entire east wall of the boiler house was blown out, crushing a lunchwagon in an adjoining parking lot, in which the three victims were eating. A 300-ft brick stack remained standing, and no serious damage was done to the boilers or the suspended-steel bunker above them.

As pieced together by *Power's* editors from statements by the District Attorney's office, insurance investigators, and the Fire Dept, the explosion story starts in the fuel-handling system. Horton's has been burning hard pitch for the last seven years. This fuel, the end-residual of tar distillation, has a high heat content and is relatively free from sulphur and ash. It is in the form of small flakes, and delivery trucks empty into a bucket conveyor which lifts the fuel to the top of the boiler house, where it is dumped into a suspended-steel bunker. From the bunker, the fuel is gravity-fed to a pulverizer, and then, in powdered form, to burners set in the boiler furnaces. The powdered pitch is burned with secondary air, in a fashion similar to conventional pulverized coal firing.

Dust from the conveyor and from the bunker, where the fuel is dumped, has been a nuisance, and attempts have been made to remedy the situation. One step, which may have contributed to the explosion, was the separation of the bunker floor from the three lower floors of the boiler house by installing planking from the sloping sides of the bunker to building walls. Although effective in reducing the amount of dust in the boiler room, this arrangement probably tended to concentrate dust in the upper compartment and to cut down ventilation.

At the time of the explosion, repairs were being made to the housing of the conveyor, which was inside the building, to stop seepage of dust into the boiler room. Fuel was being loaded into the conveyor just before the blast and the conveyor was running. One theory is that welding on the conveyor enclosure ignited the air-dust mixture. While there is little doubt that the real cause was the existence of an explosive fuel-dust and air mixture, there is no likelihood of determining whether a welding flame, defective wiring, or some other spark was the igniting agent.

Detroit Stoker Celebrates 40th Anniversary

Detroit Stoker Co is this month celebrating its 40th anniversary with a special program stressing the many advances made since the first Detroit stoker was built in 1898. Automatic stokers

were then almost a curiosity. Boilers were hand fired and smoke departments were just being established with the idea of eliminating the smoke nuisance.

That was 40 years ago. Today the Detroit Stoker plant has grown from a modest plant in Atwater St, Detroit, to a multi-acre plant in Monroe, Mich.

Dexter P Cooper Dies, Sponsor of 'Quoddy Project

Dexter P Cooper, consulting engineer, Eastport, Me., brother of the world-famous engineer, the late Hugh L Cooper, died at Boston, Mass. on Feb 2, following a heart attack. Perhaps history will remember Mr. Cooper longest for his ill-fated Passamaquoddy tidal-power project, to which he gave so much time, energy and financial resources.

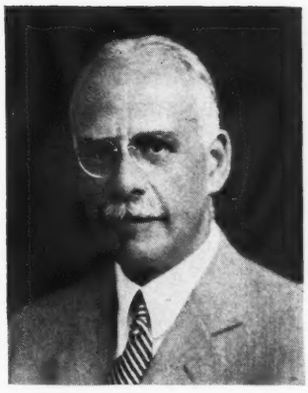
In his early years, Mr. Cooper was closely associated with his brother in many power projects, including the hydro plant at Keokuk, Iowa, where he was in immediate charge of construction. In 1913, he went to Maine as general superintendent for Hydraulic Engrg Co, ultimately making his summer home on Campobello Island in the Bay of Fundy opposite Eastport, Me. At that time he became interested in the possibility of developing power from the tides that surge through the narrow channels along the bay, and in 1919 he put forward a definite plan for harnessing Passamaquoddy Bay tides, a plan that would have cost over $100,000,000. But its international charac ter, great cost and limited market for the vast amount of power that had to be sold to bring the project even within the bounds of practicability proved to be insurmountable obstacles.

After 16 years of effort, Mr. Cooper had to compromise on the much smaller scheme to harness tides in Cobscook Bay in Maine, for which President Roosevelt authorized, in 1935, an initial expenditure of $10,000,000. Work on the project was continued for about a year, and then abandoned with about $8,000,000 spent on small dams and preliminary work for large dams. Dams and hydraulic structures proved to be far too costly in relation to possible power output, no firm power could be produced from the tides alone, and a proposed pumped-storage plant to supplement the tidal plant turned out to be impracticable.

OBITUARIES

ISAAC F BAKER, 87, for many years plant engineer at General Electric's Lynn, Mass, factories, with the title of general superintendent, died at his home in Lynn on Feb 17.

CHARLES W STONE, 63, consulting engineer of General Electric Co, died at his home in Schenectady on Feb 3 after an illness that had confined him to bed for nine weeks. After being graduated from University of Kansas in 1894, Mr. Stone was with Franklin Electric Co of Kansas City, W S Hill Electric Co of New



Bedford, Mass., and Hancock Equipt Co of Boston for two years each. In 1900 he joined G E Drafting Dept, and the following year was in switchgear engineering. Mr. Stone was named manager of the Lighting Dept, now known as the Central Station Dept, in 1912. He continued in this position until 1928, when, at his own request, he was relieved of managerial responsibilities and made consulting engineer of the company.

C M BREWER, 57, president of California Oregon Power Co, died in Medford, Ore. on March 2. Since 1902, Mr. Brewer had been associated with a number of power companies in the western states, including Consumers Power Co, Northern States Power Co, Northern Idaho and Montana Power Co, Western Gas & Electric Co, and Mountain States Power Co.

ARTHUR W CASS, 56, superintendent of the Lyons, Neb. municipal light and water plant for more than 20 years, died recently of a heart attack.

FRANK COLLINS, president of Toledo Pipe Threading Machine Co, died on Feb 12. Mr. Collins, president of this company since its organization in 1902, is succeeded by W W Vosper, who was one of the original founders and has been associated with Mr. Collins since that time.

WILLIAM H THOMAS, president of The Direct Separator Co, Inc, Syracuse, N. Y., died on Feb 10. Mr. Thomas had served this company continuously for 53 years as employee and company official.

PERSONALS

GEORGE H BUCHER, executive vice-president of Westinghouse Electric & Mfg Co, has been elected president. Frank A Merrick, president since 1929, was elected vice-chairman. Mr. Bucher and Mr. Merrick have both been with Westinghouse for many years. The former started with Westinghouse in 1909, and began his career as a coil winder.

DR. ERNEST E WACHSMUTH has been appointed consulting engineer for American headquarters of Leipzig Trade Fair, 10 E 42nd St, New York, N. Y. Dr. Wachsmuth will be in a position to secure information on all phases of German machinery, equipment and manufacturing processes. He sailed recently for the Spring Fair and *Power* has arranged to receive a report from him to be published in the June number. This will stress German diesel developments.

CLAYTON S COGGESHALL has been made general assistant to R B Beale, manager of Turbine Div, Central Station Dept, General Electric Co. He was formerly manager of turbine sales, Lynn River works.

G SINDING-LARSEN has been appointed chief engineer of Pittsburgh Piping & Equipment Co. Coming to America from Norway in 1921, he gained wide experience in power and process piping with J G White Engrg Corp, Consolidated Edison Co of N. Y., and Sanderson & Porter Co. consulting engineers. With the latter company, Mr. Sinding-Larsen was engaged in design and erection of piping for West Penn Power Co.'s Springdale and Windsor, W. Va. power stations. After completing the latter project, he joined Pittsburgh Piping, where he has been active in research and development of creased bends and corrugated pipe.

J C LANG, formerly works manager, Automatic Business Machines, Inc, Pittsburgh, has resigned to become chief engineer with Brooke L Jarrett & Co. industrial engineers of the same city.

LEON A WATTS has been appointed to succeed the late Samuel Moore as General Supt of Allis-Chalmers Mfg Co's Service & Erecting Dept. He joined that company in 1903 and during his many years of shop and field experience has handled practically every line of equipment built by that organization, includ-

Meetings

American Institute of Electrical Engineers—*Summer Convention, June 20–24, Washington, D. C. H H Henline, secretary, 33 W 39 St, New York, N. Y.*

American Society of Mechanical Engineers—*Semi-Annual Meeting, June 20–24, St. Louis, Mo. C E Davies, secretary, 29 W 39th St, New York, N. Y.*

Edison Electrical Institute—*Annual Meeting, June 7–9, Atlantic City Auditorium, Atlantic City, N. J. M B Woods, secretary, 420 Lexington Ave, New York, N. Y.*

Midwestern Power Conference—*Sponsored by Armour Institute of Technology, April 13–15, LaSalle Hotel, Chicago, Ill. L E Grinter, dean of Graduate Div, Armour Tech, conference director.*

National District Heating Assn.—*Annual convention, June 28–July 1, Lord Baltimore Hotel, Baltimore, Md. W H Sanford, secretary-treasurer, 1317 Spruce St, Philadelphia, Pa.*

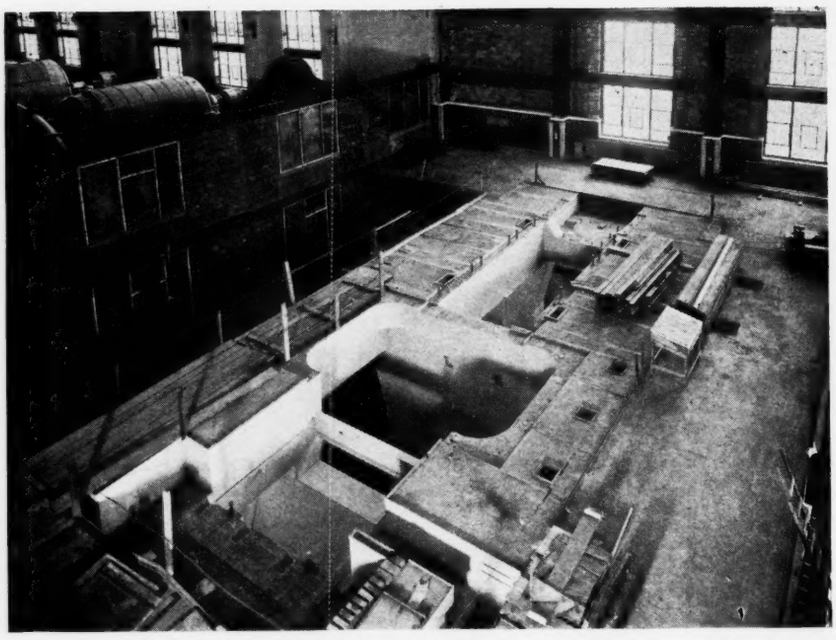
Smoke Prevention Assn.—*32nd Annual Convention, May 17–20, Andrew Jackson Hotel, Nashville, Tenn., Assn office, 139 N Clark St, Chicago, Ill.*

ing many of the larger steam and hydroelectric power units.

DR. ROBERT E DOHERTY, president, Carnegie Institute of Technology, has received the 1937 Lamme Medal of the AIEE, for "his extension of the theory of ac machinery, his skill in introducing that theory into practice, and his encouragement of young men to aspire to excellence in this field."

EDWIN W NICK, president of Northern Equipment Co, Erie, Pa., has been named a member of the National Cooperation Committee which is engaged in formulating a program of greater cooperation between industry, the President, and Congress. Among other members of the committee are W L Batt, president of SKF Industries; Lammot du Pont, president, E I du Pont de Nemours & Co; F W Lovejoy, president, Eastman Kodak Co.

W W CALDWELL has resigned from J. G White Engrg Corp to become vice-president and general manager of the building-construction firm of Iglehart, Caldwell & Scott, Inc, New York, N. Y.



DELRAY LEGS

On this foundation will stand the new 75,000-kw, 900-F, 815-lb turbine for Delray Station. Initial operation is planned for Dec. 1. Photo courtesy *The Synchroscope*

NEW PLANT CONSTRUCTION

McGraw-Hill Business News Department Is Prepared to Furnish a More Complete Daily Service

Calif., San Diego—San Diego Consolidated Gas & Electric Co., plans expending $1,500,000 (in 2 parts), first an item of about $250,000 for completing projects started in 1937, such as new boilers and turbine installation Station B, the Hillcrest Sub-station and National City Sub-station; second, balance of $1,250,000 for work starting in 1938, consisting entirely of small projects and new extensions of gas and electric distribution systems for new customers and improvements in and replacements of these distribution systems. The principal projects included in the latter are Chula Vista Sub-station $40,000, new feeder equipment Station "F" $15,000, new feeder equipment, Hillcrest Sub-station $15,000, replacement of gas main in 30th St. $55,000.

Colo., La Junta—City Council plans special election May 10 to vote $497,000 bonds to construct 2,000 kw. plant (Diesel).

Colo., La Junta—Southern Colorado Power Co., W. N. Clark, genl. mgr. 4th and Main Sts., Pueblo, has proposed to City Council that it will build a $500,000 steam power plant if granted a franchise. Council has planned to submit proposal to voters for $700,000 municipal plant.

Conn., Hartford—Hartford Electric Light Co., 266 Pearl St., Hartford, plans constructing power plant improvements and finishing South Meadow Station, here and vicinity, $2,900,000; also plans constructing improvements, during 1938, $127,000.

Idaho, St. Anthony—Municipality plans constructing hydro-electric power plant. $165,000.

Kan., Alma—City, c/o City Clerk, will not construct power plant. City, which recently voted $30,000 bonds for power plant and distribution system, has decided to purchase distribution system from private power company and purchase electricity wholesale. Paulette & Wilson, Natl. Reserve Life Bldg., Topeka, engrs.

La., Bossier City—Bossier City, c/o H. L. Fuller, mayor, plans election in May to vote bonds for constructing lighting and power plant and distributing system, incl. two 525 hp. and 1,000 hp. engines, either Diesel or electric. $375,000. Garrett Eng. Co., c/o owner, and 308 Hughes St., Houston, Tex., engrs.

Md., Baltimore—Consolidated Gas & Electric Light & Power Co., Lexington Bldg., light and power improvements, here and vicinity, day labor and separate contracts. $5,422,000. Private plans.

Md., Sykesville—H. P. Hopkins, archt., 10 East Mulberry St., Baltimore, soon lets contract altering and constructing addition to power house equipment, alterations and additions to water supply system, at Springfield State Hospital, for State. P.W.A. project.

Mich., Kalamazoo—City plans constructing electric light and power plant. $270,000. Burns & McDonnell, 107 West Linwood St., Kansas City, Mo., engrs.

Minnesota, North Dakota, South Dakota and Illinois—POWER PLANT IMPROVEMENTS—Northern States Power Co., 15 South 5th St., Minneapolis, Minn., and subsidiaries, completing installation of 46,700 hp. generating unit and 2 boilers at Riverside Station, installing 4 additional 13,000 volt lines in Minneapolis, Minn. Div.; extending new 4,000 volt feeder from Snelling Substation, installing new regulating equipment at High Bridge Steam Station to serve 4,000 volt feeder to be extended from this station, installing auxiliary equipment known as pilot exciters on generators at High Bridge Steam Station, extending additional 13,000 volt line to Forest Substation, installing relay equipment on large oil circuit breakers at High Bridge Steam Station, Stockyards Substation and Rogers Lake Substation, St. Paul, Minn. Div.; increasing transformer capacity at Waseca, New Richland and Rosemount Substations, at Faribault, Minn. Div.; rebuilding 13,000 volt line between Rapidian and Good Thunder, Mankato, Minn. Div.; installing new 800 hp. generating unit in St. Cloud hydro plant, replacing small unit, installing new boiler in Brainerd gas plant, rebuilding two 33,000 volt lines, one between St. Cloud and Monticello and other between Monticello and Buffalo, increasing capacity of Glenwood Substation and St. Joseph Substation at St. Cloud, Minn. Div.; installing additional 65,000 volt transformer capacity at Minnesota Valley Steam Plant, Granite Falls, Minn., increasing capacity Montevideo Station, Southwestern Div.; installing new 6,700 hp. generating unit and boiler in Fargo Steam Plant, and new boiler there to replace 2 smaller boilers at Fargo, N. D. Div.; installing new steam-driven boiler feed pump at Grand Forks Steam Plant, Grand Forks, N. D. Div.; rebuilding 13,000 volt line between Baltic and Garretson, Sioux Falls, S. D. Div.; partially rebuilding 33,000 volt line between Galena and Hazel Green, Galena, Ill. Div.; also additions to service station in Minneapolis, Minn., and other various substations elsewhere; installing voltage regulators of additional transformer capacity and of lightning arrestors, pole replacements; also constructing rural extensions throughout entire system, by company forces. $6,810,740.

Minn., Westbrook—Village soon takes bids electric light and power plant, equipment and distribution system. $78,000. Will issue $28,200 bonds for same. Buell & Winter Eng. Co., 508 Insurance Exch. Bldg., Sioux City, Ia., engrs.

Mo., Columbia—City, c/o D. E. Crane, supt. Water & Light Dpt., constructing municipal power and light-plant addition, by hired labor. Mayor soon lets contract furnishing, installing boiler, steam generating unit, boiler feed pumps circulating water pumps power piping, wiring, low pressure exhaust heater (closed type) and auxiliary equipment in power plant addition, for City, c/o D. E. Crane, supt. Water & Light Dpt. W. M. Cauthorn, city engr. Burns & McDonnell, 107 West Linwood Blvd., Kansas City, engrs.

Mo., Jefferson City—State Building Comn., E. Eagan, secy., 42 Capitol Bldg., taking new bids altering and constructing additions to power plant, steam distribution piping, power piping, primary electrical distribution system, water distribution system, at State Penitentary. $600,000. Bids Feb. 1 rejected.

Mo., La Plata—City soon takes new bids constructing power plant and distribution system. $100,000. Owner is not arranging for grant. E. T. Archer & Co., 609 New England Bldg., Kansas City, Mo., engrs.

Neb., York—City held special election Mar. 16, to vote bonds for constructing power plant, furnishing, installing generating plant with 3 Diesel powered units, and distribution system. $475,000. R. Fulton, 2327 South 19th St., Lincoln, engr.

N. Y., Oswego—Central New York Power Corp., Electric Bldg., Buffalo, and 15 Broad St., New York, plans constructing steam generating plant, $9,500,000. Maturity probably summer of 1938. N. Gibson, c/o owner, engr. H. M. Cushing, c/o owner, Buffalo, chf. mechanical engr.

S. C., Greenwood—Finance Bd. for Greenwood Co., E. L. Brooks, chn., Court House, soon lets contract constructing earthen dam, involving 39,000 cu. yd. core trench and 551,300 cu. yd. rolled earth excav., 37,300 cu. yd. excav. for rock fill toe; also power house and spillway, involving 30,000 cu. yd. earth and 30,000 cu. yd. rock excav., and other appurtenant structures for Buzzard Roost Hydro-Electric Project. $600,000. Part of $3,000,000 project. D. T. Duncan Eng. Co., Greenwood, engrs.

Tenn., Chattanooga—Electric Power Bd. of Chattanooga, at office N. J. Simmons, secy., Municipal Bldg., soon lets contract three 1,667 kva., four 3,333 kva., and four 5,000 kva. transformers, for Substations 1, 3 and 6, $105,000; also for oil circuit breakers for above $100,000.

Tex., Brenham—P.W.A. has withdrawn $140,000 grant for construction of a brick concrete power (electric) plant and distribution system at request of City. So P.W.A. is eliminated from the project. City will now likely soon finance the project. $175,000. Garrett Engr. Co., Box 1726, Houston, engrs.

Tex., Lancaster—City, R. Holder, mayor, plans municipal electric light plant. $80,000. Election held Mar. 1 to determine definitely the proportions of plant, type, etc.

Tex., Robstown—City, c/o J. W. Kellan, mayor, soon takes bids constructing power and light plant, incl. three 525 hp. engines and generators, $250,000. Garrett Eng. Co., Box 1726, Houston, engr.

Que., La Tuque—St. Maurice Power Corp. soon takes bids constructing 162,000 hp. hydro-electric plant, incl. dam, power house and 4 generating units. Part of $12,500,000 development. Private plans.

Make this Test . . .

and See the Difference

SCORE CARD

As a good golfer keeps his eye on par, so alert buyers of Motor Control should buy on the basis of standards, not competitive claims

	PAR	Cutler-Hammer	Any Other Make
1. Price & Rating	10		
2. External Appearance	5		
3. Internal Appearance	5		
4. Reliability	10		
5. Size	10		
6. Accessibility	5		
7. Light Interior	5		
8. Rubber Mounting			
9. Flexibility of Mounting	3		
10. Reliable Overload Protection	10		
11. Quick Make & Break	10		
12. Lock Safe Feature	5		
13. Dead Back	5		
14. Accessible Terminal Screws	2		
15. Parts Interchangeable with Magnetic Starter	5		
TOTAL	100		

CHALLENGER

The Cutler-Hammer Bulletin 9115, Size 0 Manual Starter welcomes comparison.

RATINGS: NEMA Size 0. Max. Rating (Polyphase) 1½ H.P., 110 V.; 2 H.P., 220-440-550 V. Max. Rating (Single Phase) 1 H.P., 110 V.; 1½ H.P., 220-440-550 V. List Price: Single phase $6.00; 3 phase $7.00; 2 phase 4 wire $11.00.

CUTLER-HAMMER INVITES YOU TO MAKE AN IMPARTIAL COMPARISON OF MANUAL STARTERS

A group of electrical experts were asked recently to list every desirable feature in an A. C. Manual Starter. The 15 features they named are listed in the score card at the left.

Against this analysis of the "perfect" starter we suggest you compare the Cutler-Hammer Bulletin 9115, Size 0 and any other starter made. You can use the voting system indicated or any other arrangement that brings a total of 100%. We merely suggest that you compare any or all starters to "par" and let your own judgment decide.

Certainly, from the standpoint of the buyer, nothing could be more fundamental, more fair . . . and we know, more convincing. Order one of these new Bulletin 9115 starters today, returnable for full credit (specify voltage, horse power, frequency and number of phases), and make this startling comparison yourself. CUTLER-HAMMER, Inc., *Pioneer Manufacturers of Electric Control Apparatus,* 1358 St. Paul Ave., Milwaukee, Wisconsin.

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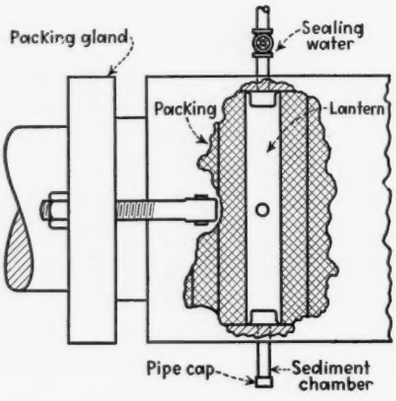
C-H

Practical Aids to Operation



Dirty Sealing Water Causes Packing Trouble

SHORT LIFE was the rule for the packing of condenser circulating-water pumps in one plant. Several brands of packing were tried, but all lasted only a few weeks. In addition to expense and inconvenience of frequent renewals, we discovered that the shaft showed noticeable erosion and abrasion.

Sealing water for the packing was supplied from the house-service line at about 75 lb pressure. This water was pumped through twin strainers which removed the smaller particles of debris, leaves and sticks. After heavy rains and spring thaws, there would be considerable amount of fine grit and sand in suspension, that would pass through the strainers. Several times, when the circulating-pump packing was removed, the lantern was found blocked with sand and mud. This sediment blocked the lantern and shut off sealing water to the packing rings, and overheating soon added to the destructive action of the sediment.

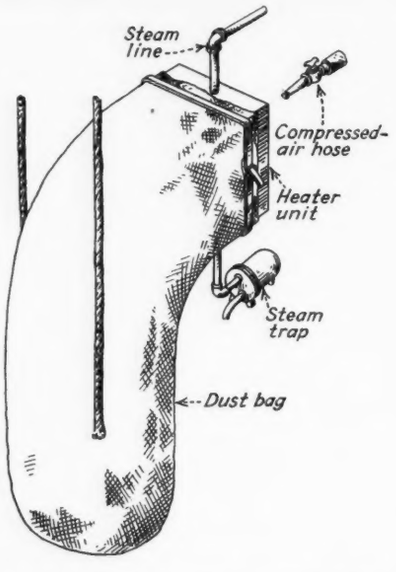
To eliminate this difficulty, condensate was used for sealing and cooling the packing glands of condensate pumps so that house-service water was narrowed down to a comparatively few pumps. On these, a ½-in. hole was drilled and tapped into the bottom of their stuffing boxes. In these holes were screwed capped nipples. Once a week during normal water conditions, lanterns were cleaned by shutting off the sealing water, removing the cap from the nipple and turning on water. When the river was muddy, sediment chambers were flushed out daily. Cleaning the chamber was but a matter of a few moments. No packing difficulties have been experienced since this installation, other than from normal wear.

Chicago, Ill. C A ARMSTRONG

Regular Cleaning of Unit Heaters

UNIT-HEATER radiators must be cleaned at least once each season, depending upon the atmospheric conditions. In foundries, where considerable dust is produced by the shakeout, heaters may require cleaning once a week. This condition was corrected by supplying the units with fresh air from outdoors, which avoided not only the extreme dust condition, but also improved general foundry atmosphere. In machine shops, heaters should be cleaned at least twice each season, especially in shops where cutting compounds are used.

Frequent cleaning is necessary in paint rooms, depending on location of



the units with respect to spray-painting operations. A unit heater close to an inadequately ventilated spray booth filled up solidly within two weeks. The trouble was remedied by moving the heater about 10 ft and running a fresh-air duct to outside the building. In offices, unit heaters will require cleaning at least once each season. Janitors should be instructed to use a compound if they must sweep with a broom. The sanitary way to take care of an office is with a vacuum sweeper.

Unless your maintenance department is properly equipped to handle the work of cleaning unit heaters, there will be many complaints, to say nothing about inefficiency of the heating system. Before starting the job, visit your local tent and awning manufacturer and obtain a dust bag about 4 ft square and 12 ft long made of a good grade of cotton flannel, with the fuzzy side inside. All seams should be double-sewn French type for added strength. This bag will take care of 400 cfm of air.

Place the neck of the bag around the frame of the unit heater and fasten it there by a hoop-steel band or with a strap. Two ropes on the other end of the bag, one on each top corner to support it, as in the figure, make for maximum effective surface. The outer end is left lower than the heater so that dust will accumulate in it.

Finally, the heater is blown with compressed air, using hose and nozzle. Blowing is done from the back side of the heater into the bag. I have found that this kind of cleaning bag gives satisfactory results and recommend it where good housekeeping is a plant policy as well as an economy.

Philadelphia, Pa. C C HERMANN

Underground Flues Require Attention

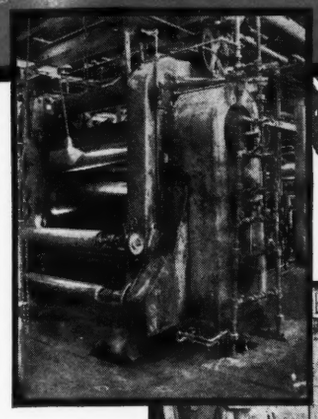
UNDERGROUND passages for flue gas are usually to be avoided, but location of buildings and equipment sometimes make it impossible to place them otherwise. Maintenance of these flues must be given careful consideration. External corrosion of the flue is largely up to the designer who specifies the material. If unprotected steel duct is selected, there is little the operating personnel can do but let it corrode and avoid drainage of pipe lines near the duct. Cast iron, concrete, tile, and other corrosion-resistant materials have been used with more or less success for underground gas ducts.

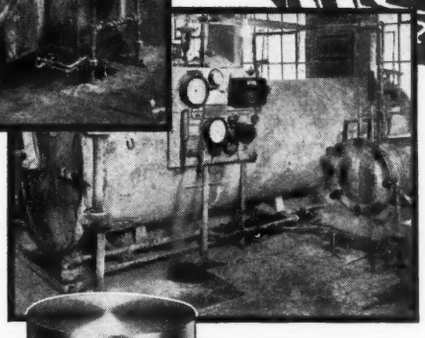
Removing soot and flyash from underground lines is usually much more of a problem than from aboveground ducts. In some cases, it is possible to tunnel under the duct at strategic points and install a soot conveyor. Clean-out doors, at least 12x16 in. in size, should be installed where there are sharp turns. Avoid a change of size in underground ducts wherever possible, but if a size change is necessary, provide a clean-out door in the larger sized duct.

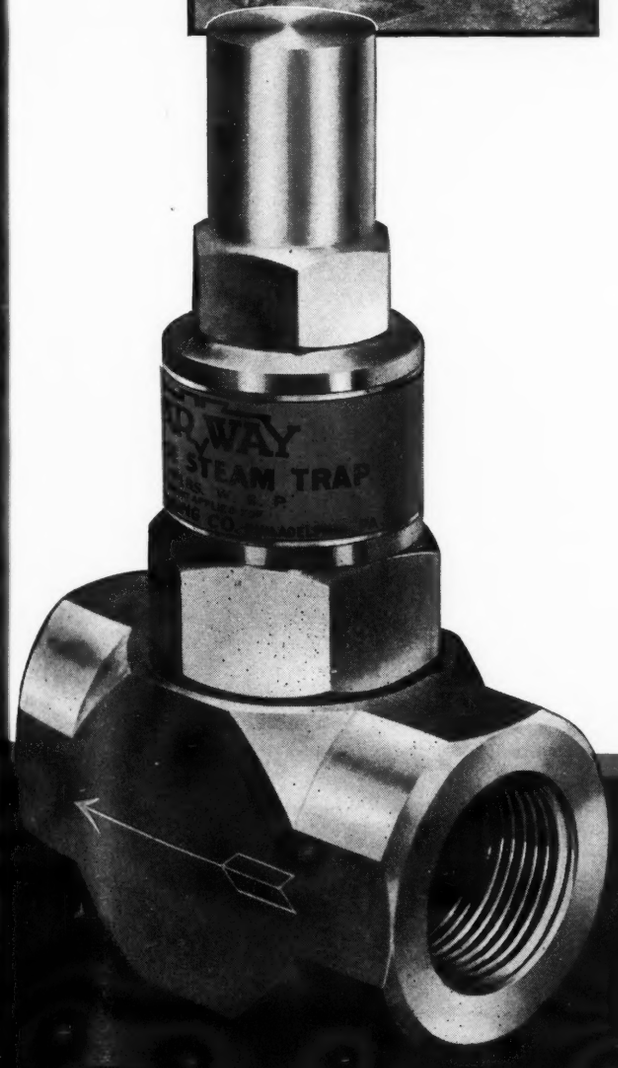
Frequency of cleaning will depend on how much the duct size exceeds that required for proper draft. If a duct has large capacity, cleaning will not have to be as frequent as where draft is effected by small soot deposits. If cleaning is difficult and unpleasant to the personnel, this task is often neglected. One plant which burns pul-

LEE of Conshohocken Tires

57 YARWAY IMPULSE TRAPS







57 Yarway Impulse Steam Traps installed in one year, from January to December '37, do their part in helping to make a great tire.

These traps are installed on all kinds of equipment—vulcanizers, steam platten presses, calenders, unit heaters, etc., etc.

Traps are working under pressures ranging from 10 lbs. at the unit heaters to 125 lbs. at the calenders.

Yarway Traps are replacing less efficient devices in many plants. In most cases, as at the Lee of Conshohocken plant, installations start with a single trap or two, and grow as more traps are needed.

Why? Because here is the one trap that meets all requirements—six sizes, from ½" to 2", factory set for pressures up to 400 lbs. —and frequently cheaper to install than to repair an old trap.

Try a Yarway Trap! Let it demonstrate its efficiency and dependability, show you real savings in both installation and servicing costs. It is a new kind of trap, entirely different in principle—simple, small, light, of rugged bar-stock construction with heat-treated stainless steel valve and seat and other structural as well as operating advantages you should know about. See your mill supply house—or write us for Catalog T-1722.

YARNALL-WARING COMPANY
100 Mermaid Ave., Philadelphia

YARWAY

IMPULSE STEAM TRAP

verized coal had a rather severe furnace explosion because defective draft in an obstructed underground flue created a positive furnace pressure on a sudden change in load. The flue was 4x4 ft in cross section and was found filled with soot to within 10 in. of the top at a bend. A trap door in the top of the flue, into which a man had to climb and shovel out soot, had been forgotten for years.

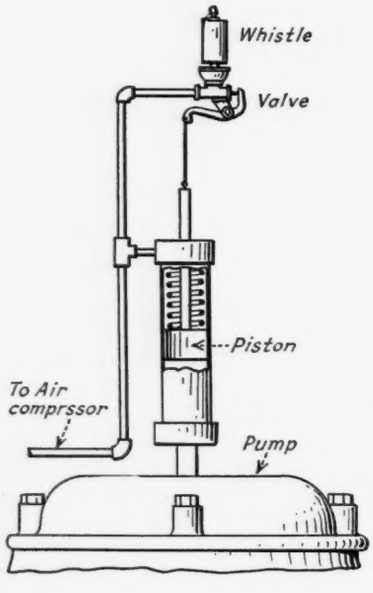
Safety precautions cannot be overstressed. No one should be allowed to enter a flue without a substantial chain around him connected to an outside support. A rope may burn off. Station a man directly outside at all times when a workman is within. All boilers connected to the flue should be off the line, and all dampers closed tightly and tagged or locked. Men have been killed in flues by return blast from a furnace explosion when the boiler was connected. Thrust a light stick with paper wired on its end into several places of all soot piles before approaching them closely. If the paper does not char or feel hot to the hand, it is usually safe to work.

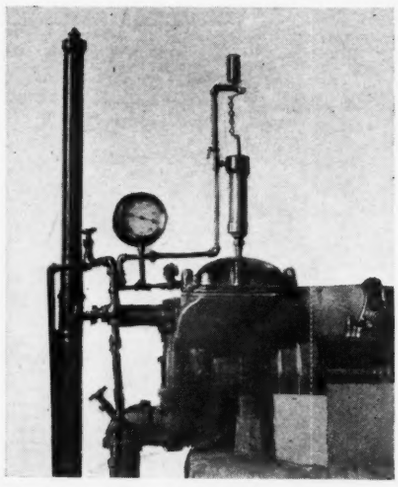
All men engaged in this work should wear safety shoes (foundry type) and dust masks. Ventilate the flue of any possible gas before entering. By keeping all connecting boilers off the line, and all boiler dampers locked or tagged shut, no danger should result.

New York, N. Y. HARRY M SPRING

Circulating-Pump Alarm

THE DIAGRAM and photo show an alarm on a circulating-water pump, to sound if the pump shuts down. This pump supplies jacket water for air compressors, and if the engineer fails to start the pump with the compressors, the latter might overheat before the lack of cooling water was discovered.





A cylinder with a spring-loaded piston is installed on the discharge side of the pump. The piston rod connects to the lever of an air whistle. As long as water pressure is on, the whistle valve remains closed. If water pressure fails, the spring pushes the piston downward to open the air valve and sound the whistle.

Pittsburg, Kan. W J LAPWORTH

Why Unit Heaters Won't Heat

UNIT heaters are prone to fill up, with dirt and oily soot, so solidly that fans cannot force air through radiators. In many unit-heater designs fans are conventional axial-flow or propeller type. Disk fans possess a satisfactory efficiency at low resistance, however, for as the unit-heater radiators fill with dirt, air-flow resistance increases and fan efficiency decreases.

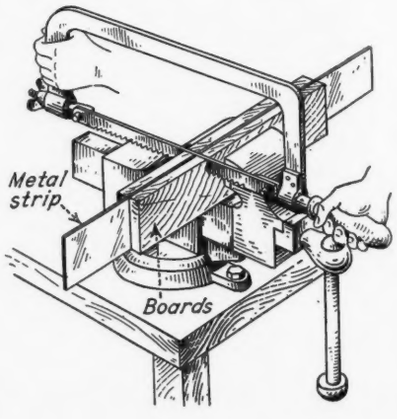
To one familiar with operation of disk fans, a change in the noise volume will be noted with increased resistance. This is not of much value in manufacturing plants where noise is common. In offices, however, a noisy fan can often be traced to a dirty radiator. Another simple way to determine dirt loading of a unit heater is to test the fan for blow-back at the center around the hub. When heater resistance increases, air handled by the blades doubles back and blows out around the center of the fan.

The most convenient and sure method of knowing just how the heater is working is to take velocity readings with an anemometer. The face of the heater radiator should be divided into imaginary squares and readings taken in each of them. Their average is then the average air flow for the entire area and the multiplication of these two averages gives total air volume discharged by the heater at the given temperature. It is then a simple matter to convert this volume to standard air by applying the correction factor for the given temperature. For all practical purposes, about four readings with the anemometer taken in the four quadrants of the unit are sufficient.

Philadelphia, Pa. C C HERMANN

Uses Hacksaw on Thin Metal

THIS may not be a new trick to all readers, but it's a handy one. When a thin sheet stock is a little too much for hand shears, the job can be done with a hacksaw (see illustration) by placing the material between two flat boards and clamping in a vise. No teeth will be ripped out of the hacksaw blade and the cut will be rapid and clean.



Penacook, N. H. C H WILEY

Practical Scraper for Tool Kits

THERE are no more useful small tools to the power-plant maintenance man than a good set of hand scrapers. With the thought that not all *Power* readers have the same ideas on design of such tools, the drawing presents a few that I call my best and handiest ones. *A* is made from a flat piece of sheet tool steel, formed vee shape and ground, leaving a tang to use in a handle. This type is easy to grind for sharpening and stoning. The draw scraper *B* is also flat stock, but can be formed from a file—a good material for any scraper. The end is forged out fan shape and then given a right angle bend.

Scraper *C* is double ended from round stock. It is useful on large bearings and does not require much

Fatigue AND VALVE LIFE

In picking steels for Edward valves, fatigue tests help compare probable spans of useful life.

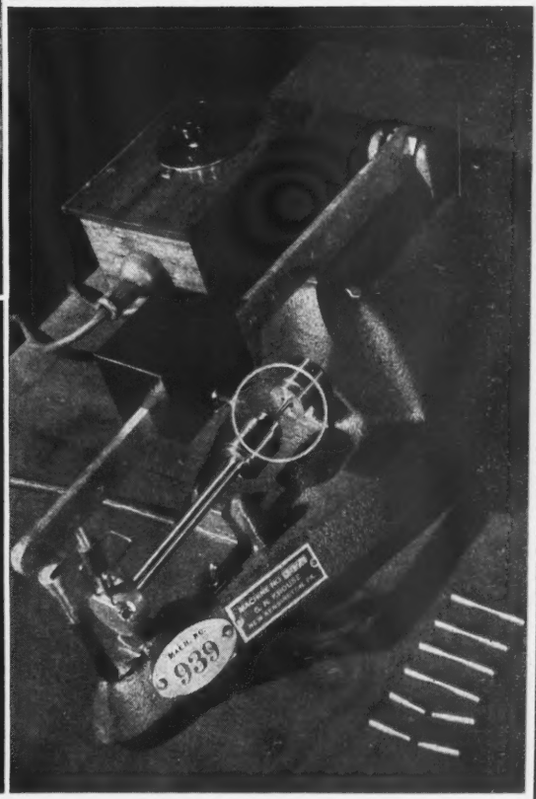
Chemical composition, heat treatment, and fiber structure, affect ability to endure repetition and reversal of stresses. Some types of steel soon develop slip bands, and then fracture; others withstand punishment — within limits — for indefinite periods; still others are erratic.

Results of Edward tests establish bases for conservative design.

• • •

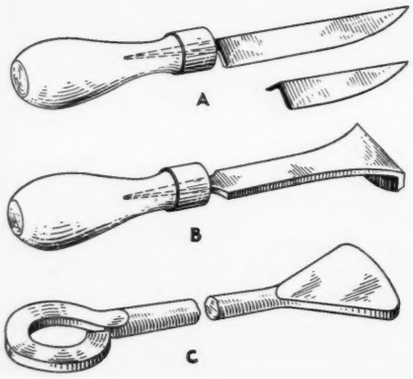
THE EDWARD VALVE & MFG. CO., INC.
EAST CHICAGO INDIANA

Here's a new fatigue test (top) —in Edward physical laboratory— in which a seat and disk are subjected to pulsating compression stress, 600 cycles per minute, under actual operating temperatures. Detail of assembly is shown in middle picture; stem and bonnet threads of Edward Fig. 2688 stop valve are used to apply load—at 850 F—to disk and seat. Left: Rotating beam machine, in which specimen has to stand ten million reversals of stress to prove it will stand up at that load forever. Right: 10,000 rpm high-speed cantilever machine.



Edward Valves

Stop • Check • Non-return • Blow-off • Feed Line • Relief • Bleeder Line • etc



skill to make. The ring end is first drawn out in a long rectangular flat, then formed while hot into a ring over the anvil horn and flattened. The other end takes a broad fan shape.

Boston, Mass. L W ROGERS

High-Condensate Alarm for Heating System

ON the Empire State Building heating system, the condensate-return vacuum pump failed to start when it should have. This condition was discovered only after water began to run out of the automatic vents on the return tanks. Some form of automatic alarm was therefore needed to signal when the condensate level rose above a safe point.

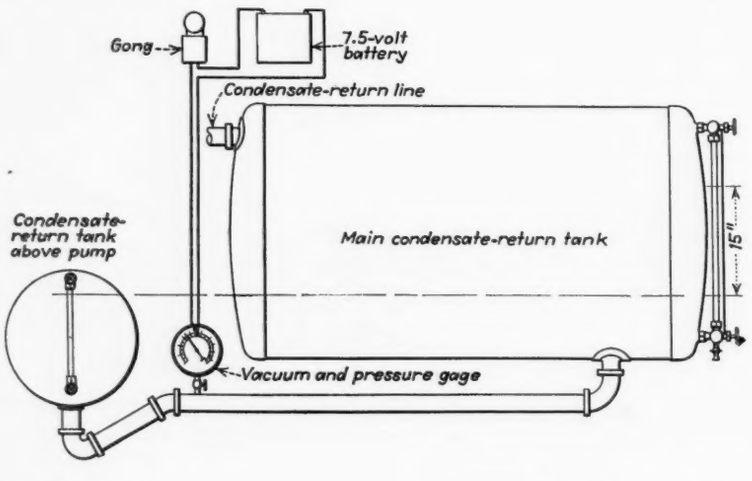
As shown in the figure, condensate returns to a large tank, from which it drains to a smaller tank. The pump is below the latter, which serves to maintain static head on pump suction. A float switch, operated by water level in this tank, starts and stops the pump automatically.

The problem of providing an alarm proved to be rather simple. It was found that the water level in the main return tank could rise 15 in. or more above normal without being unsafe. This change in level gave a sufficient head differential to return a vacuum-gage pointer from normal-vacuum conditions on the system to atmospheric.

A combination vacuum-pressure gage on top of the condensate-pump service tank was removed and equipped with two contacts that could be bridged by the pointer when it returned from vacuum to atmospheric pressure. This gage was installed on the pipe between the two tanks, see diagram, and connected to gong and battery as shown.

Now, if the pump fails to start, either because of blown fuses, a defective float or other causes, when the water rises 15 in. above normal level in the main tank, the gage pointer closes the contacts to sound the alarm. It is tested periodically by opening the switch on the pump motor and waiting until the main tank fills to where the gage contacts close.

New York, N. Y. C F WENDLAND
Chief Engineer



Simplified Method of Fixing Oxygen Sample

IN USING the "Winkler" method of determining dissolved-oxygen content of boiler-feed or other water in a plant, it is usually difficult to introduce the fixing reagents without exposing the sample to atmosphere. This is especially true in cases where the sample is not piped to the laboratory and must be fixed in the plant. Even with the most careful manipulation of pipettes and burettes, a relatively large area is exposed to surrounding atmosphere.

We have been able to simplify fixing and reduce the exposure with hypodermic needles. Graduated needles of 1.5-cc capacity are equipped with replaceable points. A $\frac{1}{8}$-in. hole was cut in a regular bulb-type sample collector, Fig. 2. In our case, the hole was burned through with hydrofluoric acid, then a piece of gum rubber about one inch square placed over the hole and secured by rubber bands.

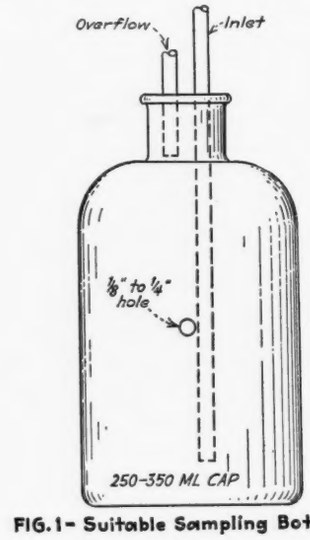


FIG. 1- Suitable Sampling Bottle

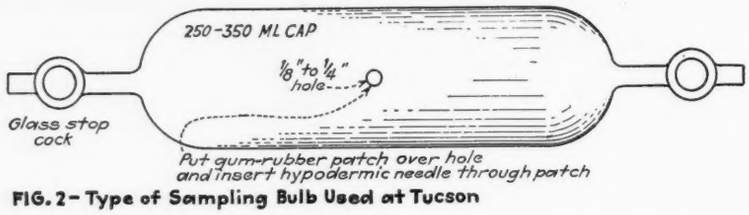


FIG. 2- Type of Sampling Bulb Used at Tucson

The sample is collected in the usual way and fixing solutions added by puncturing the rubber patch. Separate syringes and needles are used for each solution. The only possible contamination of the sample comes from the small area of the needle itself.

The syringes are not expensive compared to pipettes or burettes and are much more convenient. The needles are renewable and last 6 months or more, with the exception of the acid needle. The rubber patch is replaced after about a dozen fixings. Gold needles may be obtained for the acid syringe, and by rinsing in distilled water after using, a needle should last 3 to 6 months. Grease all plungers after using.

With this method of fixing, we have been able to obtain samples that show zero dissolved-oxygen content, which was not possible with other fixing procedures.

Tucson, Ariz. BILL MADDOCK

Left—Nalco laboratory directors and their staff. Below—The general laboratory. Special research is carried on in additional departments.

Make this YOUR water treatment laboratory, too!

THERE is no getting around the fact that physical facilities DO make a difference in the service you can expect to get when it comes to feedwater treatment. This explains why Nalco has spared no expense in giving its customers the finest and most modern laboratories obtainable and an expert staff to man them in its new Chicago headquarters. There is virtually nothing that Nalco technicians have wished for but what has been provided. And all for the purpose of giving better service! We will be glad to show you what this can mean to you. NATIONAL ALUMINATE CORPORATION, 6222 W. 66th Place, Chicago, Ill.

An interesting illustrated booklet has been printed describing Nalco's new headquarters. We will be glad to send you a copy. No obligation.

ANY WATER **NALCO SYSTEM** ANY PRESSURE

Inquiries other than domestic, *except those from U. S. Possessions, Canada and Mexico,* should be addressed to ALFLOC LTD., Bush House, Aldwych, London, W. C. 2, Eng. Canadian inquiries should be sent to ALUMINATE CHEMICALS LTD., 372 Bay St., Toronto, Ont.

Current Comment

Who Should Adjust Safety Valves?

IN January *Power*, there is a short article by J H Williams relating to blowdown on safety valves. In view of the new ASME Code, it would seem better to have all safety valves returned to the manufacturer for any adjustment, since Par. P-281 states that blowdown adjustment shall be made and sealed by the manufacturer. Therefore, in order to relieve the plant engineer and inspector from any responsibility in the event of an accident, it would seem prudent to ship safety valves to the manufacturer for proper adjustment.

It should also be observed that Par. P-285 states that, when a new spring is installed because of changed conditions at the plant, the safety valve shall be adjusted by the manufacturer, who shall furnish and install a new plate, as per Par. P-273 of the Code.

In many cases, safety valves leak and are ground in. This affects blowdown, so if the engineer is permitted to repair the safety valve, he also will have to adjust the blowdown. In view of the fact that the safety valve is of utmost importance, the prudent engineer will insist upon the correct changes and adjustments being made by the manufacturer.

Buffalo, N. Y. JOHN J TIMMONS

Cleaning Oil-Cooler Tubes

[The following two articles are additional answers to the question on cleaning oil-cooler tubes, and supplement the answers that appeared in March *Power*, pages 95 and 96—ED]

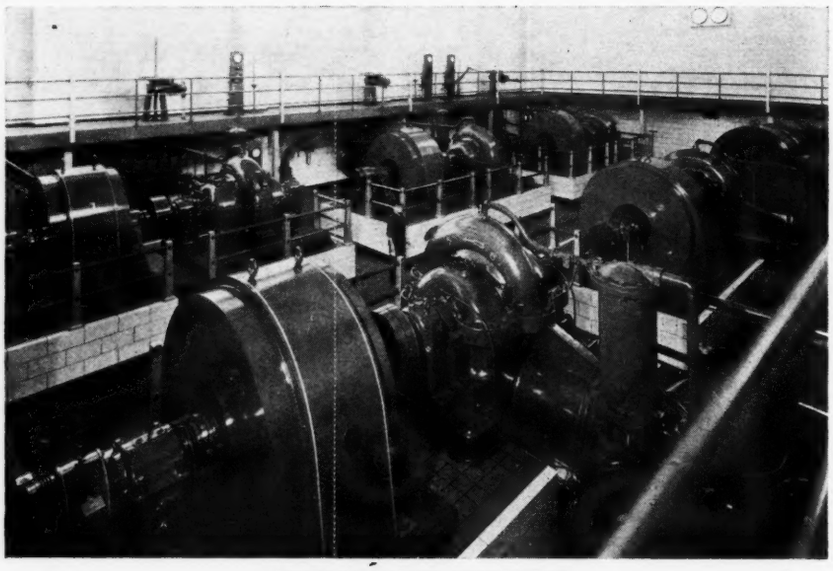
WE HAVE oil coolers of the type described by TDO in January *Power* and have experienced the same trouble. We use "Wyandotte Metal Cleaner," one lb to a gal. of water, boiling for three or four hours until the tubes are perfectly clean. The bundle is removed, and placed in a tank large enough so that it is entirely under water.

Roswell, N M R F ENTROP

A SOLVENT called "Toluene" seems to be the perfect answer for cleaning oil-cooler tubes. Also called methyl-benzene or toluol, toluene resembles benzene and is a base for many dyes, explosives, and aromatic compounds, and is inflammable. Any chemical jobber can supply it, at a cost of approximately $0.46 per gal.

The tube bundle is cleaned by immersing it in a tank containing the solvent. The process takes about 24 hours, but can be hastened by circulating the solvent with compressed air or by other means. The tube bundle is then removed and thoroughly washed and blown out with water. The process may have to be repeated several times if the tube bundle is badly choked. Toluene does not attack the metal but will remove every trace of carbon and oil residue from the tubes and restore them to their original brightness. The solvent can be used repeatedly.

Kansas City, Mo. H B KENNEDY



AWESOME BUT EFFICIENT

This battery of pumps, enough to awe the average man, deliver 50,000,000 gpd of water against a head of 136 ft for Chicago's Cermack Pumping Station. Pumps are driven by 1500-hp, 514-rpm Westinghouse motors, 97.9% efficient, which is claimed the highest efficiency of any motors yet built

Designed for Contortionists

WHILE reading "Designed for Contortionists," February *Power*, page 81, I was reminded of a similar instance in the pipe tunnel of our building. In this tunnel, two steam lines run parallel with expansion joints about 6 ft apart. Pipes above and below make it impossible to get to the expansion joints of the line nearest the wall.

When a gasket had to be replaced on this joint, it was necessary to burn off a section of the outside line and weld on a pair of flanges. Now, when we have to work on the inner expansion joint, we remove this section of pipe and by some diligent contortioning we are able to reach it. I heartily agree with the author's suggestion that the designing engineer consult with the operating engineer before construction gets started.

Cleveland, Ohio T C BROCK

CONGRATULATIONS to Mr Walter Thomas and to *Power* for the article aptly titled "Designed for Contortionists." The miserable mixtures called power plants which have been passed on to operating engineers should be more frequently discussed along these lines. More than once, in trying to correct some atrocious piece of so-called plant design, we have wished that the man who designed it could be forced to run it as part of a special course in design.

For the good of the cause, we would like to pass on the story of a hotel boiler room equipped with two horizontal low-pressure boilers for building and water heating, and a vertical firebox boiler, at higher pressure, for kitchen-steam supply. Hard water found in this part of the country soon made it necessary to put new flues in the vertical boiler. Not only was there no spare unit to meet the demand for "high-pressure" steam, but no provision had been made for replacing tubes. It was necessary to completely disconnect the boiler and lay it gently on its side, before old tubes could be cut out and new ones put in place. When this was finished all that remained was to stand the boiler up again and remake all the steam, water, and gas connections.

New York, N Y EGBERT DOUGLAS

More About the Soot-Blowing Problem

THE questions and several answers in August and December, 1937, issues of *Power* show that soot blowing deserves considerably more attention than it sometimes receives. Soot is a product of incomplete combustion. It consists mainly of carbon, cooled beyond its ignition temperature before combustion is completed. When it occurs in large amounts, it is usually an indication of improper furnace design, turbulence, or faulty operation of combustion equipment. Flyash, sometimes loosely classi-

If the "skin" could be magnified and peeled off, you might see something like this,

DO YOU KNOW that the life of your boiler depends upon an unbroken film of iron oxide so thin that it can scarcely be measured!

As amazing as this statement may sound, it remains a fact,—scientifically and practically.

The conditioning of water must be such that it will provide a protective wall that will separate the boiler water from the metal. When the water is properly conditioned, this protective wall becomes a "skin" of iron oxide —integral with the metal and immeasurably thin.

If this skin breaks or becomes lost, corrosion or "pitting" begins. Water not properly conditioned, contacting these broken areas, does not rebuild this protective coating. Rather, it continues to dig pits and furrows on bright, unprotected steel until it penetrates the thickness of the metal. Destruction is the result!

Water that is properly conditioned immediately forms this thin film of iron oxide, rebuilds it when it becomes broken, and prevents destruction. That means lasting boiler life!

Protecting boiler life in this manner is the job that The Buromin Company (in connection with Hall Laboratories) is doing in power plants—large and small—everywhere. Write for additional information. Our engineers will gladly cooperate with you in getting maximum boiler life at your plant.

CORROSION RESULTS

Unretouched photograph of cross section of a boiler tube that was destroyed, in only a few months, by pitting. Correct conditioning of the boiler water would have prevented this destruction.

This advertisement on "pitting" tells of only one of the evils that develop in boilers. Other evils that are costly or destructive are scaling, embrittling and carry-over. The Buromin Company corrects and eliminates all of these with equal thoroughness.

THE BUROMIN COMPANY, 300 Ross Street, PITTSBURGH, PA.

BUROMIN

THE BUROMIN COMPANY
300 Ross St., Pittsburgh, Pa.
Gentlemen:
Please send me, without obligation, your booklet "Buromin—for clean boilers, continuous service, enduring economies, lasting satisfaction."

Name .....

Position ..... Company .....

Address .....

City .....

fied with soot, has many of the disadvantages of soot, but is not a product of incomplete combustion.

A coating of soot ⅛ in. thick is about as effective in resisting heat flow as a layer of asbestos insulation ⅝ in. thick. A rise of 100 F in flue-gas temperature is not uncommon when tubes become soot coated. This heat loss represents close to $1000 a year for unnecessarily burned fuel in the average 500-hp plant.

There are five recognized methods of removing soot from boilers in general use: hand brushing, hand blowing with compressed air, hand blowing with steam, automatic blowing with compressed air, and automatic blowing with steam. Compressed air may cost slightly more than steam, but has a number of points in its favor. It does not emit a blast of water over tube surfaces, the case with an improperly drained steam blower. Also, chances of external boiler corrosion by condensed steam dripping from the blowers are eliminated. Compressed air should be used if steam pressure is below 75 lb.

Soot should be first blown from surfaces nearest the fire, then progressively following the path of the products of combustion between the baffles. In this manner, soot is chased along from behind, and not blown back on surfaces already cleaned.

When hand lancing, especially when a man is at the front of an hrt boiler, the operation should be carried out with full draft. If oil, pulverized coal, or natural-gas burners are used, considerable experimenting may be necessary to prevent dangerous flarebacks. It has been found that blowing soot with the burners off is not always safe because soot blows back into the firebox, and dust explosions may result. Conversely, a full fire is not conducive to effective soot removal. At least one burner should be turned on just enough to prevent its being extinguished by furnace puffs. This applies also to automatic soot blowing.

Always drain soot blowers thoroughly before opening. Wet soot does not blow off. Repair leaking soot blowers immediately. Steam leaks may cause corrosion of the boiler; air leaks are costly. Adjust soot blowers so that jets do not impinge directly against boiler parts. The sand-blast effect can cause serious damage in a short time.

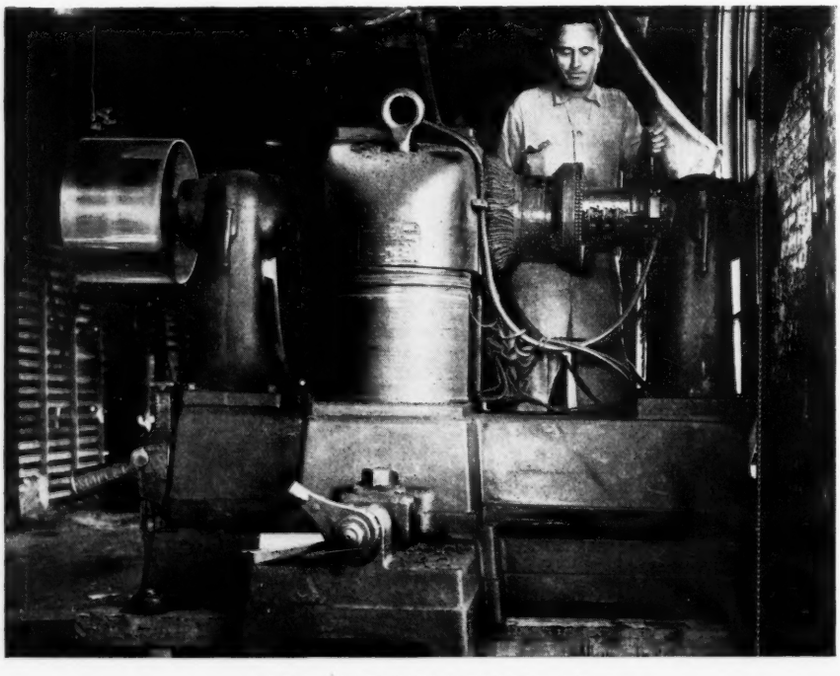
Chicago, Ill. C A ARMSTRONG

Silencer Eliminates Air-Compressor Noise

I WAS interested in the article on air-compressor installation by Harry Spring, page 74, January *Power*. Some years ago we installed a 2-stage compressor at the University of Missouri for two deep-well air lifts. On starting the compressor, we found that air entering the intake pipe produced a low moaning sound that was annoying to residents within several blocks of the plant. To suppress this noise, we installed a silencer on the intake pipe, eliminating further trouble from that source.

The deep-well water, being quite hard, deposited scale on the cooling surfaces of the air-cylinder jackets and the intercooler. This scale had to be removed about once a year to keep down air temperatures. I suggest installation of a thermometer on the intercooler so that an abnormal rise in temperature can be seen before the fusible plug melts.

Columbia, Mo. A L WESTCOTT



GONE BUT NOT FORGOTTEN

Modernization of the Indianapolis Railways has made a relic out of one of the most interesting pieces of electrical equipment in Indianapolis, the first generator used to furnish electric power for street cars in that city. Built by Thomson-Houston Co., forerunner of General Electric, it was in use from 1890 until a few weeks ago

Silencers Quiet Air Compressors

IN December *Power*, R C Larkins describes the effect of expansion chambers on compressor-discharge-line vibration. We had a similar problem a few years ago where not only vibration, but deafening noise was also experienced. The installation consisted of two 100-cfm, 2-stage high-speed vertical units compressing air to 100 lb. Discharge piping was relatively short and entered receivers mounted on wall brackets directly over the compressors.

In an attempt to relieve these conditions, expansion chambers were installed in the discharge lines between compressors and receivers. These devices eliminated vibration, but the noise still persisted. It was then decided to install commercial silencers having expansion and reactance chambers to reduce vibration and suppress low pitched noises and also having a lining of sound-absorbent material to subdue high-pitched noises. These silencers completely eliminated the noise.

Richmond, Va. C R ANDERSON

More About Tempering Coal

IN AN article in November *Power*, page 674, Mr. Robert H. Kuss discusses the tempering of coal on chain grates and other types of stokers. Naturally, addition to the fuel bed of any heat-absorbing substance such as water creates speculation as to why "Water Makes It Burn Better."

Realizing that many of the reasons which Mr Kuss gives for improved combustion are logical and valid, I wish to supplement his conclusions and take issue with him only on the prime point of "why it works." For while it may be generally held that tempering improves combustion by a purely mechanical effect, there is one important effect of tempering which is not mechanical: the catalytic action of water vapor, or rather of superheated steam, in the burning of carbon monoxide. This effect extends throughout the combustion space, and may be regarded as greatest at the point of greatest carbon-monoxide formation, that is, within the fuel bed itself.

Close observation of the fuel bed on any chain-grate stoker discloses the fact that much of the surface moisture acquired in tempering is evaporated before the coal passes into the full radiant field of the ignition arch, the rising vapor being superheated. This part of the tempering moisture could be dispensed with, since it subtracts heat from the furnace and the greater part of it escapes with the flue gas. A small part of it, however, serves a useful purpose in accelerating the union of carbon monoxide with oxygen before the temperature of the gas is reduced below the combining point.

This is comparatively unnoticeable and is more detrimental to the combustion process than otherwise. It is in the

(*Continued on page 116*)

Charts DO *prove value of steam-flow type* COPES *feed water control*

Learn what results users are getting from steam-flow type COPES Feed Water Regulators. Check their charts. You'll find close water level control, and feed flows exactly correct for the most severe load fluctuations. If you want to improve the operation of your boilers, write for Bulletin 409-A, describing the new Flowmatic—the simplified two-element steam-flow type COPES.

You can maintain a practically constant boiler water level—or any other desired level characteristic—no matter how severe your load swings—with the new COPES Flowmatic. Now installed or on order for pressures from 135 to 1325 pounds.

NORTHERN EQUIPMENT CO., 411 GROVE DRIVE, ERIE, PA.

Feed Water Regulators, Pump Governors, Differential Valves
Liquid Level Controls, Reducing Valves and Desuperheaters

BRANCH PLANTS IN CANADA, ENGLAND, FRANCE, GERMANY, AUSTRIA AND ITALY . . . . REPRESENTATIVES EVERYWHERE

Get closer boiler water level control with the new

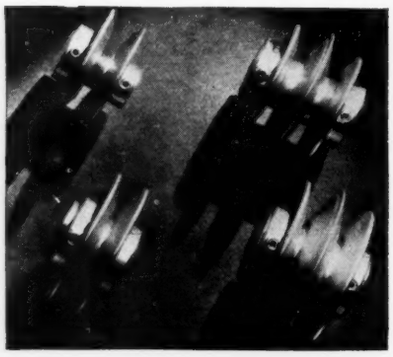
COPES

FEEDS BOILER ACCORDING TO STEAM FLOW•AUTOMATICALLY

FLOWMATIC

★ REGULATOR

What's New in Plant Equipment



Adjustable-Pitch Sheaves

SERIES of 2-groove adjustable pitch-diameter, texsteel sheaves give speed variation up to 33%. Pitch diameters are changed by stopping motor, relieving belt tension, releasing Allen-head locking screw and turning adjustable plate in or out to desired pitch diameter. Made in three sizes of 2 to 3 in., 2.5 to 3.5 in., and 3.5 to 4 in. variation respectively.

Allis-Chalmers Mfg Co, Milwaukee, Wis.

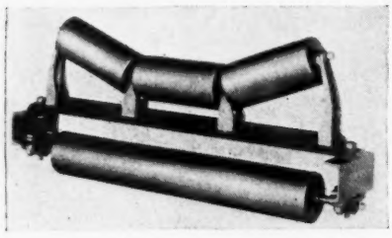
Protective Surface

FOR protecting highly-polished, painted, plated or duco-finished metal surfaces during storage, handling, etc, "Protex" is sprayed or brushed on and then preferably covered with kraft paper. Liquid sets to moisture-proof, coherent, tough skin that is opaque to light and is a good insulator of low-voltage current. Skin readily peels off with the paper, or may be pulled off in cases where kraft-paper backing cannot be conveniently applied. Remains tough and elastic up to 300 F, making it a possible insulator for condensers, coils and carbon resistors.

Haydn F White Co, 415 Newman-Stern Bldg, Cleveland, Ohio.

Belt Idler

BALL-BEARING belt idler for moderate loads is conventional 3-pulley, 20-deg troughing type. Pulleys are of 4-in.



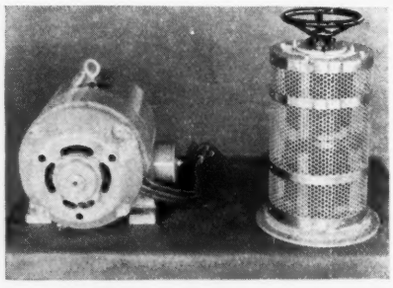
diameter welded-steel pipe with formed steel gudgeons welded in ends. Gudgeons are connected within pulley by steel tubing to prevent loss of grease. Shifts are §-in. seamless tubing held by set screws within machine-bored holes in stands. As shafts are hollow, entire idler may be lubricated from either end through pressure fittings. Base angles are inverted to shed material.

Jeffrey Mfg Co, Columbus, Ohio.

Adjustable-Speed AC Motor

WELL-KNOWN principles are combined and applied in an ingenious way to produce 3-phase motor having characteristics resembling those of a dc motor with variable-voltage control. Features include: Regulation from standstill to 150% of synchronous speed without rheostatic losses; operation on full field, which gives full torque over entire speed range; speed is practically independent of load; full-voltage starting; dynamic braking; remote and automatic speed control if desired.

Motor has laminated stator core with winding similar to that of standard 3-phase induction motor. This winding is



connected directly to 3-phase power line. Rotor core is also laminated and carries single winding similar to ordinary dc armature winding, which is connected to commutator in usual manner. There are three brush studs per pair of poles, brushes being set on fixed position, although they can be shifted if required.

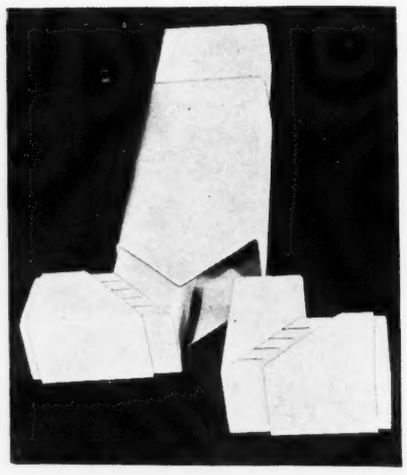
Speed regulator for varying voltage applied to rotor consists of two single-phase, induction voltage regulators in one frame, the two rotors being mounted on one shaft. Primary windings are on the rotors and connected through flexible leads to 3-phase source of power. Two secondary windings on stationary element, or stator, are connected in open-delta to give 3-phase voltage which is applied to motor brushes.

At speeds below synchronous, slip energy, which in ordinary slip-ring motor is dissipated in the external resistance, is returned to the line through the speed regulator. At speeds above synchronous, part of the energy for driving the motor is supplied to the stator and part to the rotor winding.

Cocker-Wheeler Electric Mfg Co, Ampere, N. J.

Air-Conditioning Duct

"CAREYDUCT" is made in standard double-layer sections 3 ft long. Each section consists of an inner asbestos layer or core

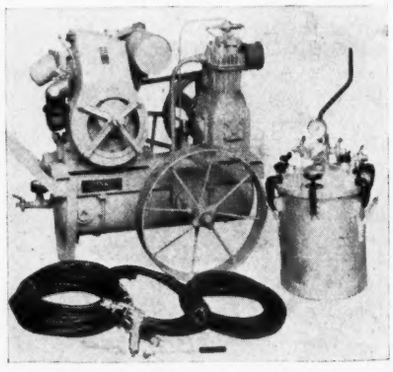


approximately $\frac{3}{16}$-in. thick. Outer shell or insulating jacket made of multiple layers of fine corrugated firmly bonded asbestos makes close sliding fit over inner core. Total wall thickness of core and jacket combined can be made from $\frac{1}{2}$ in. up to suit conditions.

Philip Carey Co, Lockland, Cincinnati, Ohio.

Spray Outfits

LINE of six mounting styles for portable paint-spraying compressors, one of which is 2-wheel hand-cart style illustrated. This can be furnished with steel wheels or pneumatic tires, for gasoline-engine or electric-motor drive

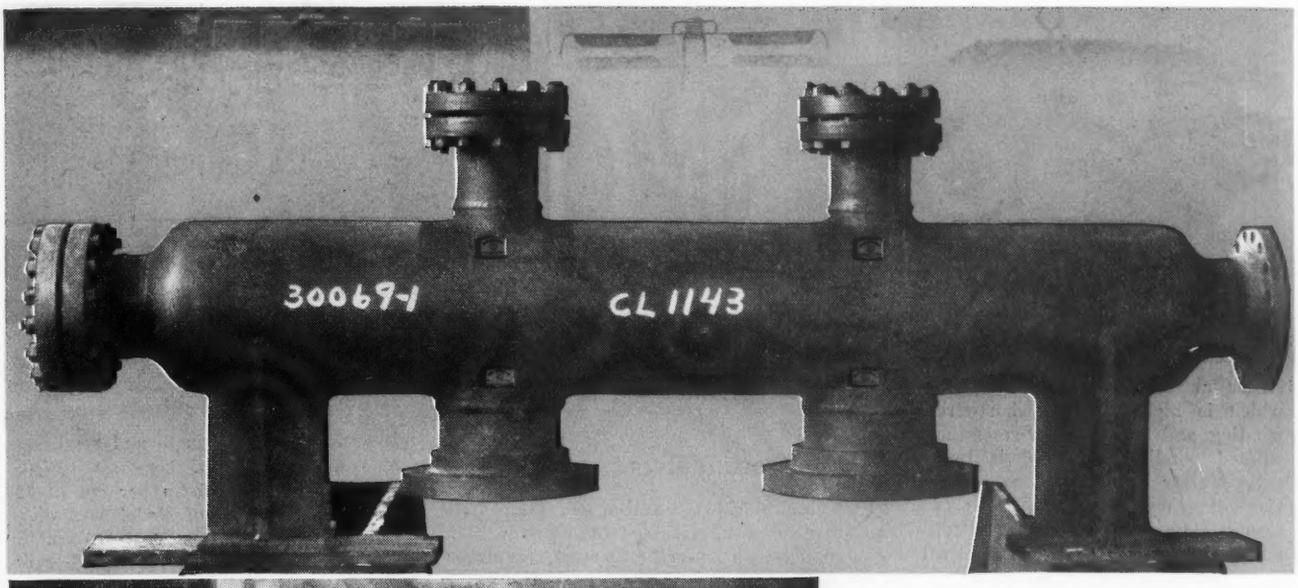


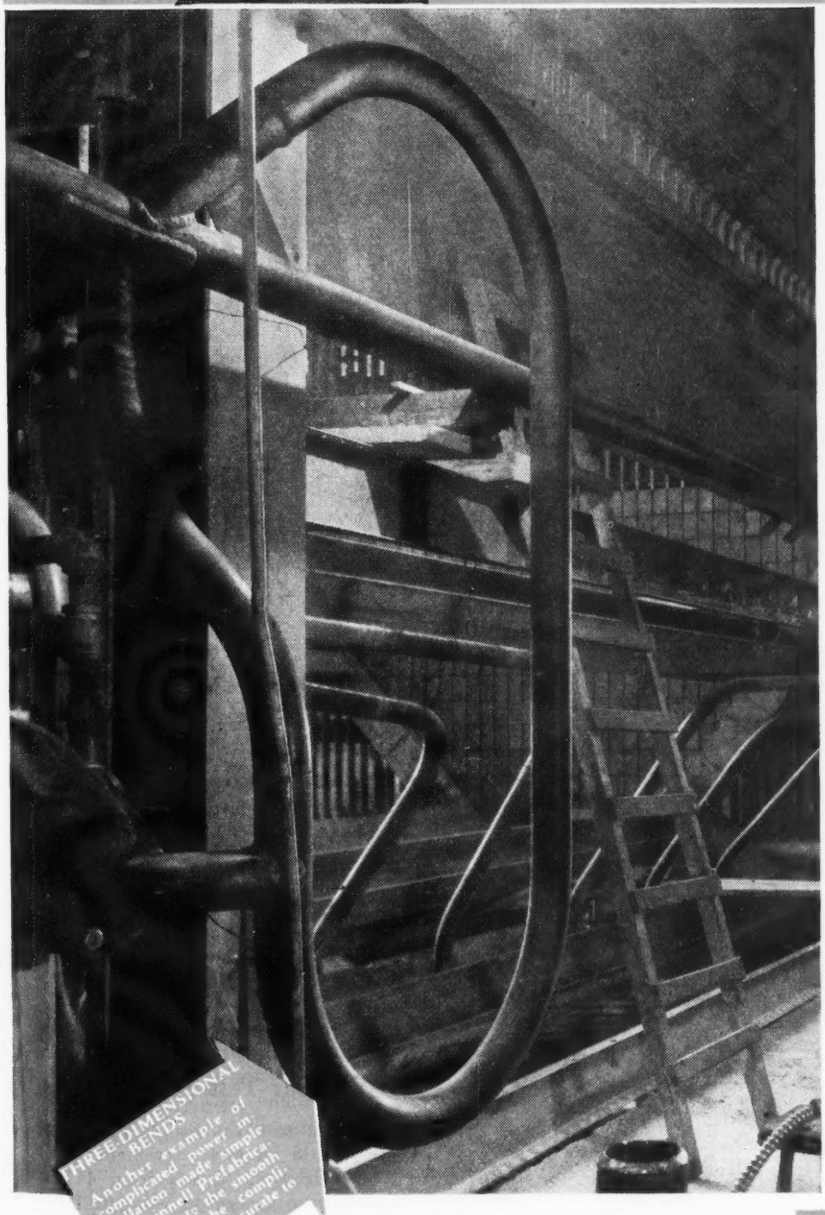
from 1½ hp to 6 hp sizes. Also newly developed are "Helmet-Type" and "Cartridge-Type" respirators for spray painting. Former has muslin hood which protects head, neck and shoulders; latter fits face with fume-tight seal and permits full vision.

Binks Mfg Co, 3111-40 Carroll Ave, Chicago, Ill.

Polyphase Motor

TYPE RT polyphase motor has low starting current, high starting torque, and good speed regulation. Has locked torque of about twice full-load torque and a locked current of from 3 to 3½ times full-load current. Rotor





THREE-DIMENSIONAL BENDS

Another example of complicated power installation made simple by Grinnell Prefabrication. Note the smooth, accurate to a degree.

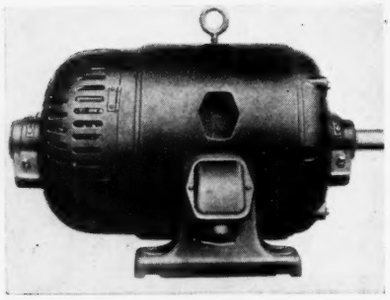
GRINNELL INTERPRETS PLANS INTO *Strength!*

Each specification of this 18" Header has been carried to exacting accuracy—the result of the interpretative engineering that is an important feature of Prefabrication by Grinnell. The outlets extruded by hydraulic machines permit each weld to be a plain circumferential butt weld.

The ability to interpret into piping the ideas and plans of engineers is one of the Grinnell "extras" by which your power and processing installations achieve strength and endurance. Thorough pretesting, delivery on schedule, ready qualification for insurance, plus many other requirements, are answered automatically when engineers say, "Give the plans to Grinnell." Send for interesting picture-story of Grinnell Prefabrication. Grinnell Company, Inc., Executive Offices, Providence, R. I., Branch offices in principal cities of the U. S. and Canada.

PREFABRICATION BY GRINNELL

WHENEVER PIPING IS INVOLVED



is primary member and carries winding which is connected to line when motor is operating. Secondary member is stator and has two windings, one of which is high-resistance short-circuited winding and other is low-resistance insulated winding. Control is by magnetic starter containing two contactors. One of these is line switch which closes immediately when button is pushed or when automatic control is energized. Second contactor short circuits low-resistance winding after a definite lapse of time and may be adjusted to suit time required to accelerate load. Ordinarily made in sizes 40 hp and larger. Completes line of polyphase motors for air conditioning.

Wagner Electric Corp, 6400 Plymouth Ave, St Louis, Mo.

Friction Tape

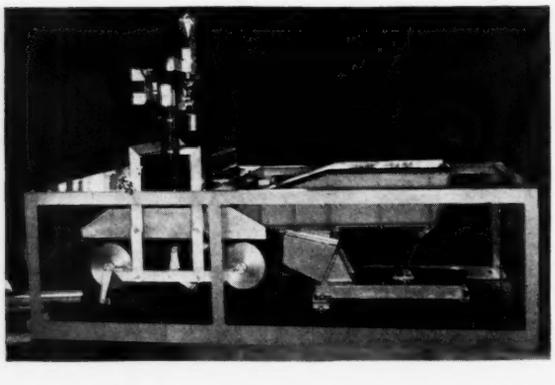
ADDITION to regular "Slipknot" black friction tape is known as Slipknot brown. Manufacturer claims that is the first basic improvement in tape industry in many years and that this product has longer life than any other commercial tape now in existence.

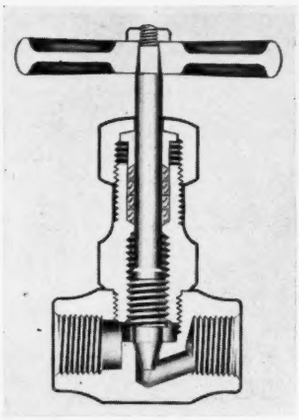
Plymouth Rubber Co, Inc, Canton, Mass.

Weigh Coal Feeder

UNIT is made up of constant-speed belt conveyor fed by "Vibra-Flow" feeder conveyor. Short-length belt conveyor is driven by constant-speed synchronous motor. Entire belt-conveyor assembly is suspended from a sensitive scale equipped with electric valves which are actuated by slightest underweight or overweight movement of scale beam. Rate of flow is controlled by varying energy to feeder trough's driving electromagnet, in turn controlled by scale electric valves, which speed up flow when load on belt conveyor gets underweight and conversely.

Syntron Co, Homer City, Pa.





Bar Stock Valves

SMALL, 3000-lb water-or-gas plug type made as disk, globe and angle valves. For connections on orifice meters, regulator leads, bypasses, gages, ammonia expansion lines, etc. May be packed when wide open under pressure. Made either in steel, Exelloy or 18-8 chrome-nickel alloy.

Crane Co, 836 S Michigan Ave, Chicago, Ill.

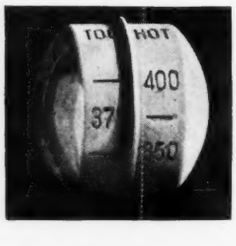
Conveyor Belt

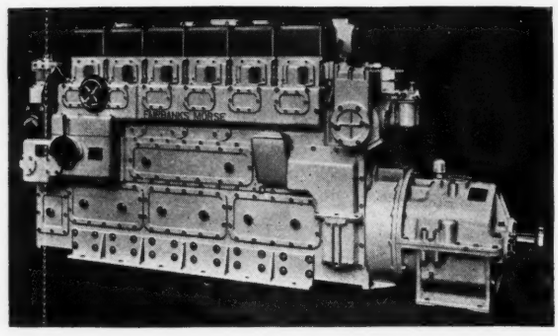
"PARANITE" gas-oil-proof conveyor belting serves coal conveyors where coal is sprayed with oil. This belt contains no rubber and is claimed not to be affected by oil. Paranite friction compound covers both sides of belt and resists abrasion of material carried as well as oil. Made in regular widths, plies and covers.

Manhattan Rubber Mfg Div, Raybestos-Manhattan, Inc, Passaic, N. J.

Thermometer

"THERMOSPHERE" all-metal floating thermometer is a chromium-plated steel sphere about 1¼ in. in diameter and with numbers around one circumference. Instrument floats in liquids and after slowly rotating to rest, figure at highest point indicates temperature. Three scales made: one designed for deep-fat frying (shown in illustration) and two general purpose instruments calibrated every ten degrees between 0 and 300 F, and between 200 and 500 F respectively. Through diameter of sphere is a shaft to which is welded inside end of bimetal spiral coil, to other end of which is welded a weight. Temperature changes cause coil to unwind, and shell revolves around shaft.—*Raytheon Mfg Co, Newton, Mass.*





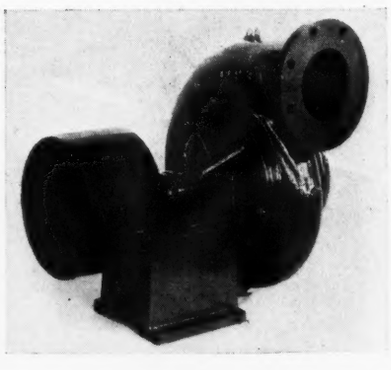
Convertible Gas And Diesel Engine

MODEL 36-A-8 built in 6- and 8-cyl combinations with 8-in. bore and 10½-in. stroke to develop 35 hp per cyl at 720 rpm. Smaller sizes of Model 36-A diesel available in ratings as low as 8 hp. En-bloc construction with individual cylinder liners; precision main, connecting-rod and crankshaft bearings; and supended or "underslung" crankshaft. Side coverplates permit quick accessibility to main and connecting-rod bearings. Double-end drive or power-takeoff from either end. Bulletin 3600-A-3.

Fairbanks, Morse & Co, 600 S Michigan Ave, Chicago, Ill.

Centrifugal Pumps

LINE of single-stage ball-bearing centrifugal pumps, Fig. 3610 (belt drive) and Fig. 3612 (motor drive) built in 18 sizes to give capacity range of 5 to 1600 gpm against heads up to 110 ft. Cast-iron casing, with suction and discharge openings cast integral. Heavy-duty ball bearing in outboard end of support head takes radial and all thrust



load. Bearing protected by triple seal on stuffing-box side; large water deflector rotating with shaft; close-clearance fit beween housing and shaft.

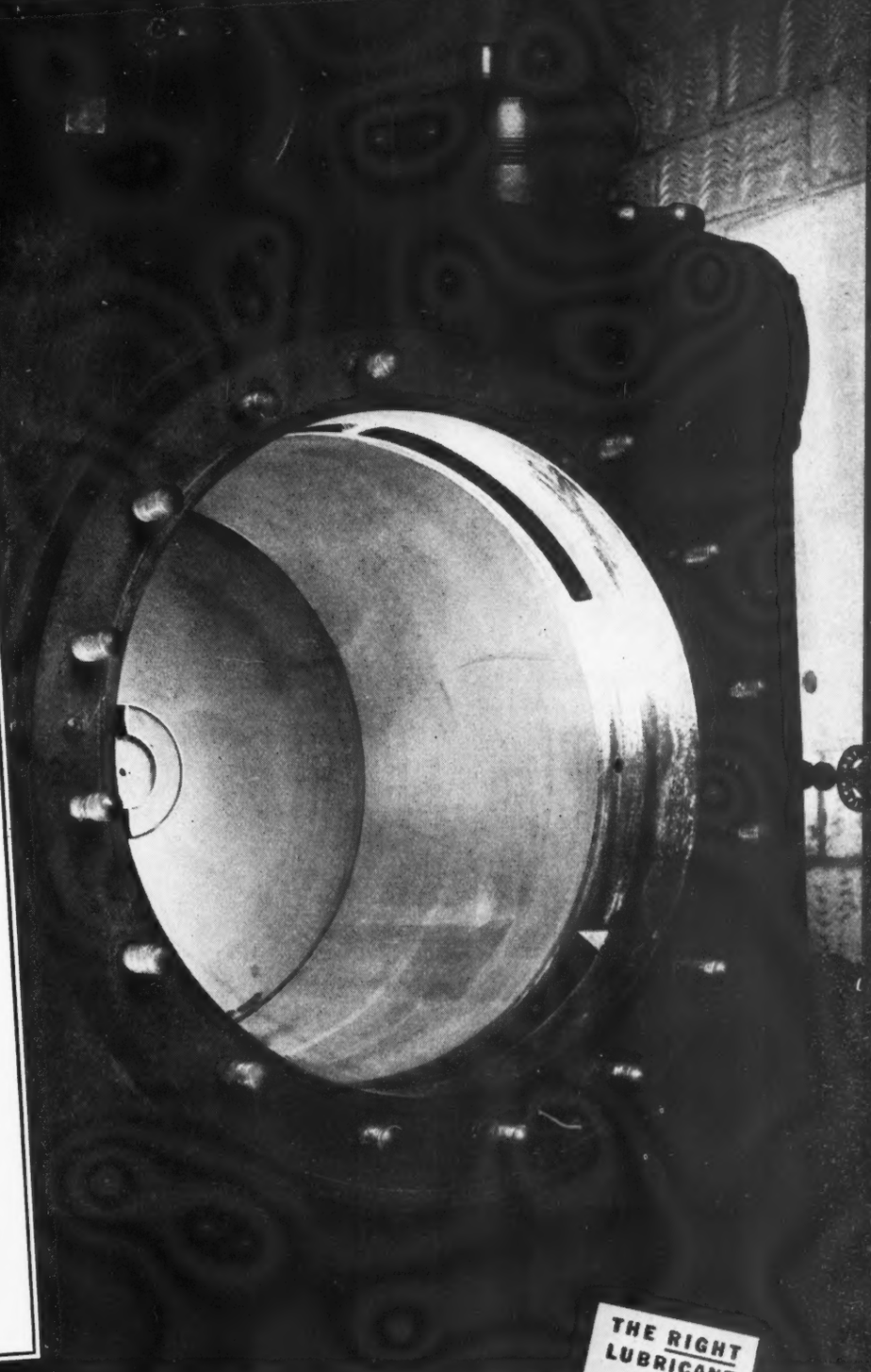
Goulds Pumps, Inc, Seneca Falls, N. Y.

Bar-to-Bar Test Set

PORTABLE test set for dc armatures is plugged in to any convenient 115-volt, 60-cycle outlet. Leads from 4 binding posts are attached to commutator, two furnishing current supply to resistance being tested, and two being terminals of drop circuit, leading to galvanometer. To compare resistance between

STANDARD OIL COMPANY'S STANOCYL STEAM CYLINDER OIL

cures cylinder scoring at this plant



THE superintendent of a central state industrial power plant was having difficulty with his Corliss engine. It simply would not pull its rated load. An inspection disclosed that the cylinder was dry and scored.

The following excerpt from his letter describes how StanoCyl and Standard Lubrication Engineering Service came to the rescue.

"We were advised by a business acquaintance to call the Standard Oil Company, which we did at once. As a result, your engineer came to our plant and made a complete inspection of the entire unit and made some minor repairs of damages that had been caused by the previous use of improper lubricants. He also gave us the brand name of products sold by your Company that would be suitable for the engine demands. These products were StanoCyl W and Polar 200 Oil.

"A stock of each product was ordered and placed in service. Our troubles have been completely disposed of. The engine pulls our full load without a tremor.

"We can, without any hesitation, recommend this product to steam engine owners who are having difficulties with cylinder lubrication."

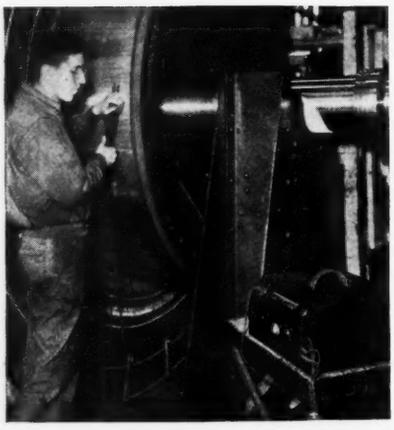
There are three grades of StanoCyl to meet all operating conditions. A Standard Lubrication Engineer will gladly recommend the grade you need. Call him at your local Standard Oil (Indiana) office or write 910 South Michigan Avenue, Chicago, Illinois.

Copr. 1938, Standard Oil Co.

STANDARD OIL COMPANY (INDIANA)

LUBRICATION ENGINEERING

THE RIGHT LUBRICANT • PROPERLY APPLIED • TO REDUCE COSTS

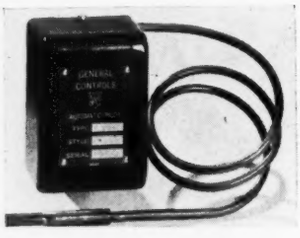


different bars, two particular ones are chosen and instrument set for 100% deflection by adjusting "current", "range" and "sensitivity" rheostats until desired reflection of light-beam galvanometer is obtained. By connecting successive commutator bars with lead extremities, resistance of coils connected to them will be indicated directly in per cent of original setting.

General Electric Co, Schenectady, N. Y.

Thermocouple Pilot

AUTOMATIC thermopilot for natural and manufactured gas. When flame is applied to thermocouple element, contact is made, allowing main gas valve to open. When gas pilot light fails, thermopilot



opens circuit to main gas valve. Made in electric contact type only. Automatically resets itself when pilot is relighted. Flexible thermocouple tube.

General Controls Co, 1370 Harrison St, San Francisco, Calif.

Oxy-Acetylene Hose

"DUOWELD" consists of two strands of ¼-in., 2-braid hose with corrugated cover which are molded together as a single unit. Cover on one strand is red, while other is green. Color dis-

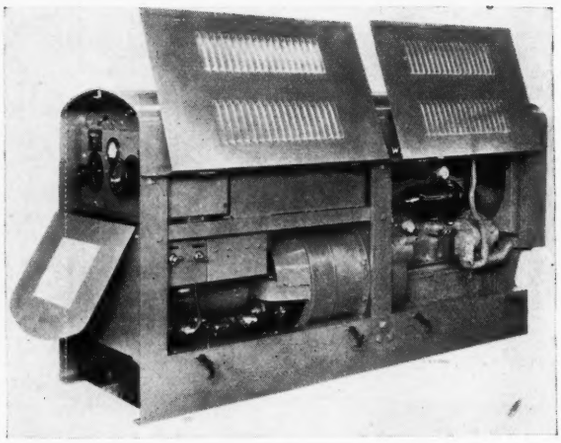
tinction aids in identifying acetylene from oxygen line. Made in 12½-, 25- and 50-ft lengths. Each length is separated and secured with metal ferrules about 1½ ft away from ends for easy attachment.

B F Goodrich Co, Mechanical Rubber Goods Div, Akron, Ohio.

Arc Welder

WELDER takes advantage of lower diesel-fuel costs. Patented engine combustion chamber accelerates turbulence of fuel and air mixture. Pintle-type fuel nozzles; five filters (3 fuel-oil filters, 1 oil-type air filter and 1 lube-oil filter). Main welding generator a 300-amp "Shield-Arc SAE" unit with dual-continuous control, has continuous voltage control, laminated magnetic circuit, and high capacity.

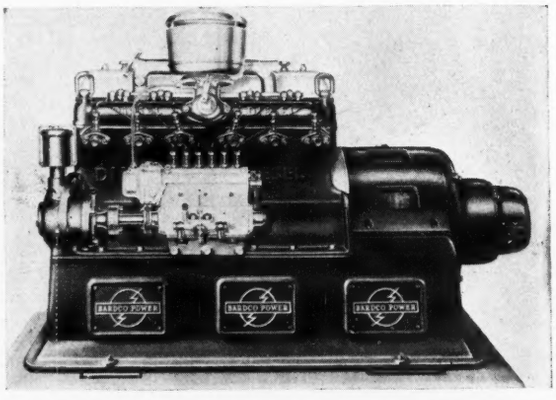
Lincoln Electric Co, Cleveland, Ohio.



Automatic Diesel Generating Unit

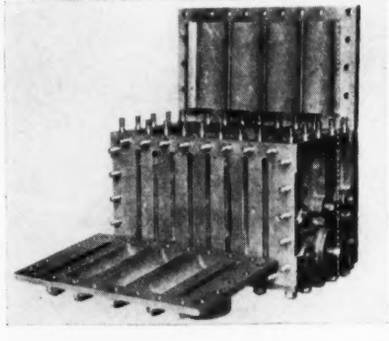
COMPACT automatic diesel-powered generating plant is designed to meet requirements of any desired voltage or frequency. Voltage regulation maintains constant voltage irrespective of load demands. Safety controls, which can be set at any predetermined point give warning signal in case of overheating or low oil supply, and stop engine before damage occurs. Oversize refining unit cleans and refines lube oil continuously as engine operates.

Bardco Corp of America, 6670 Lexington Ave, Los Angeles, Calif.



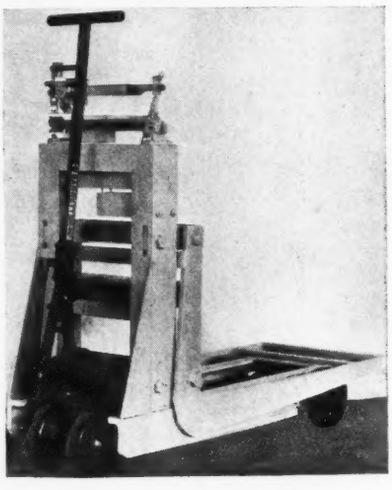
Exchanger & Cooler

HAS narrow flat passageways for both liquids. No gasketed joints to permit leakage between fluids. All passageways or transfer surfaces are accessible for cleaning by removing two heads, are streamlined to reduce turbulence and friction losses, and are very thin,



causing intimate contact between all particles of liquid and heat-transfer surface. Performance tests, liquid to liquid, are stated to have given heat-transfer rates of over 500 Btu per sq ft per deg F.

Condenser Service & Engrg Co, 310 12th St, Hoboken, N. J.



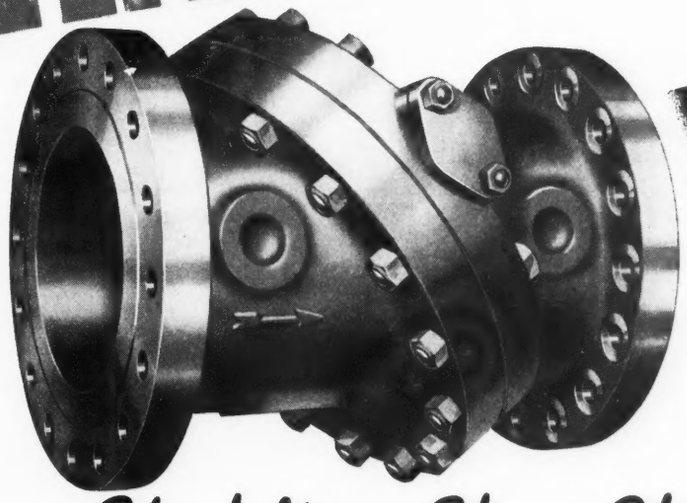
Scale Truck

COMBINATION of beam scale and lift truck, for 3500 and 500 lb capacity, has these features: scale levers mounted in vertical steel frame away from dust and dirt; liberal working clearances for scale levers; open-face poises with center reading and shadowless; scale-platform check bars fitted with double-shielded ball bearings; and platform check bars frictionless and shock-load absorbing. Either single or multiple-stroke types; may be used with any type of skids having minimum underneath clearance of 7½ in.; low maintenance cost claimed.

Barrett-Cravens Co, 3255 W 30th St, Chicago, Ill.

(*Continued on page 118*)

NO NOISE OR HEAD LOSS ALLOWED



in Chapman *Steel Non-Slam Check Valves*

CHAPMAN
Non-Slam Check Valves
ARE MADE IN THESE STEELS

Carbon Steel.
Carbon Molybdenum Steel.
Chrome Nickel Steel.
Nickel Steel.
Chrome Molybdenum Steel.
Chrome Tungsten Steel.
Chrome Nickel Tungsten Steel.

All's quiet . . . everything's under control . . . where Chapman Steel Non-Slam Check Valves are used on boiler feed lines and other power plant installations. For these valves don't flutter and slam, no matter how incessantly they open and close. Nor do they permit head loss. And because there's no noise, Chapman Non-Slam Check Valves are not subject to the customary wear on pins and bearings.

Slam is silenced by a balanced, hinge-pinned disc with a short flap that rides evenly in the flow when the valve is open. As flow slows, the disc is cushioned quickly, silently, to a drop-tight seat.

Chapman Steel Non-Slam Check Valves are made in the alloys listed at the left, and also in iron and bronze. They can be furnished for all pressure ratings from 150 to 1500 lb., and with any type of end-connection or facing. Standard ASA dimensions and specifications. Get Chapman Non-Slam economy and dependability on *your* lines. Write for complete information.

The
CHAPMAN VALVE
MANUFACTURING COMPANY
INDIAN ORCHARD, MASSACHUSETTS U. S. A.

Industrial Guide Post . . .

WHETHER it's putting in a pipeline, mending a boiler, or even taking an automobile trip, it's important to start from the right place as well as to end there. I knew that before I set a course for Cincinnati some years ago, but a farmer really brought it home to me when I got lost and had to ask the way.

"Waal," said the farmer. "Ye might start down this road, head right past Jones' cow pasture and over the hill—nope, ye cain't go thataway; road's closed afore town! Lessee, ye might swing left here 'til ye hit the country road, foller that three-four mile to Brady's store, then head west agin to the river—nope, ye cain't go thataway either. Bridge is washed out!" He scratched his head a bit, and then, "Mister, if I was you and was goin' to Cincy, I sure wouldn't start from here!"

Getting on the right track means a little pause to look things over before you plunge in. Sometimes, you'll end up by deciding you have to cut and try, sometimes your own experience will suggest an answer, but often you'll have to go to somebody else who has been through your problem and solved it.

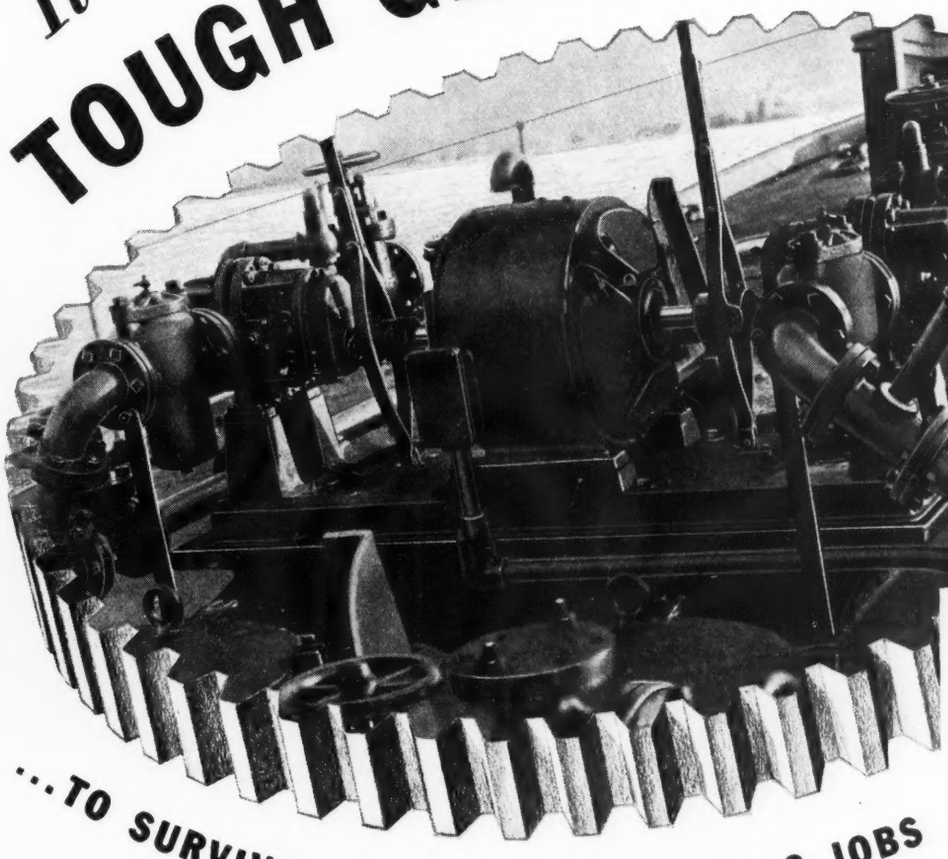
Don't worry about asking his help—usually he will in turn sooner or later hit a problem that you can solve for him. And both of you can help still other engineers by passing on your solutions. You could do a partial job by telling them, or by writing letters, but for only 100 engineers to exchange one batch of information means 10,000 letters!

It's a lot simpler to write *one* letter, and mail it in to *Power's* editors. They'll send that message on—not just to one engineer, but to the 25,000 that read *Power!* There's a lot of satisfaction for you in knowing that all these men will read it, thank you for it, and file it against the inevitable "rainy day." Besides, you'll get paid in two ways: First, your hints, and your name, will be carried to engineers the world over. Second, you will receive a contributor's check.

So often, a little help like this from a reliable source will straighten a man out when he's twisted. Remember the wayfarer who asked, "How far ahead is Omaha?" "Waal," said the rustic, "The way you're headin' it's about 23,998 mile, but turn around and it's less'n two mile!"

George Edwards
Engineer

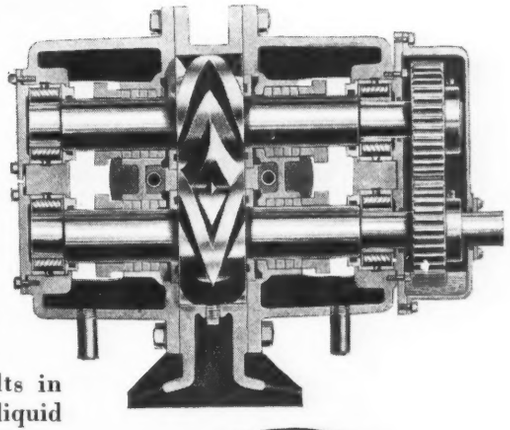
It takes a TOUGH GEAR MATERIAL...



"Heliquad" pump installation, manufactured by the Kinney Manufacturing Co., Boston, Mass., in use on an oil tanker. All timing gears are Nickel-chromium steel, carburized and hardened to produce long wearing qualities with a minimum of distortion.

Cutaway view of "Heliquad" pump showing unique rotor impeller design and Nickel alloy steel timing gears.

...TO SURVIVE THESE TOUGH PUMPING JOBS



Only a powerful pump can handle extremely viscous substances such as vaseline, wax, starch, paste, tar, etc.

But here is one, the "Heliquad", product of the Kinney Manufacturing Company of Boston, that handles all types of liquids ranging from water and gasoline to heavy fuel oils and asphalt.

Standard models have capacity ratings from a few gallons up to 3500 gallons per minute, operate at vacuums of 25 inches and higher on the suction side and discharge against pressures up to 400 lbs. p.s.i.

Obviously these capacities and pressures together with the viscosity of the materials frequently handled place a tremendous burden on the equipment—particularly the timing gears, which are subjected to unusually high stresses and wear.

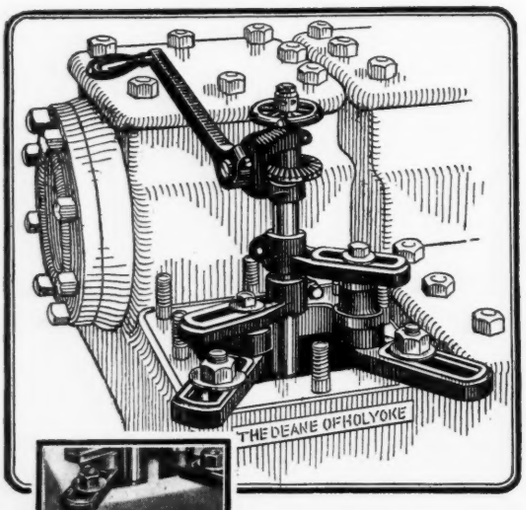
The Kinney Company solved this problem by standardizing on Nickel alloy steel (SAE 3120). The cutaway view shows this gear assembly, also the unique impellers (center) which actually mesh and yield a suction and discharge action which results in smooth displacement of the liquid free from pulsation.

The superior toughness, strength and hardness of these Nickel alloy steel gears prevent excessive gear tooth wear so that the timing of the rotors is always perfectly maintained. At the same time the dependability of the equipment and its life are both materially increased. We invite consultation on the use of corrosion- and wear-resisting Nickel alloy steels in your equipment.

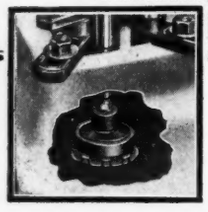
ALLOY **NICKEL** STEELS

THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL ST., NEW YORK, N. Y.

"Youd think we bought a new pump!"



That's what you will say when you reface pump seats



in place with the

DEXTER

PUMP VALVE RESEATER

Have your reciprocating pumps warped, worn or scored seats? If so—you're losing money, wasting fuel—heading for expensive repairs and delays.

Seats can be refaced smooth and true—in place — with a DEXTER Outfit, as shown above. Simply attach machine to studs on Pump Valve chamber. A few rotations of the cutter —and the seat is refaced and like new. Waste motion vanishes!

Catalog 24 describes this machine and other Dexter Machines for reseating Globe Valves and Gate Valves. Write for it.

THE LEAVITT MACHINE CO.

10 East River St. Orange, Mass.

Current Comment

(*Continued from page* 106)

fuel bed that tempering proves its worth. In the presence of water vapor driven out of the coal by the heat, carbon monoxide formed is burned to carbon dioxide, with greater liberation of heat where heat is needed. The burning of CO probably takes place, even if sufficient oxygen is present (certainly if there is a deficiency of that necessary element) by dissociation of the water vapor, oxygen combining with the carbon and the hydrogen rising to recombine with oxygen higher in the combustion space.

The more complete oxidation of the carbon within the bed, with consequent greater release of heat energy at that point, prevents even the heavier hydrocarbons distilled from the coal from remaining long in the plastic state. The plastic state may be entirely eliminated, due to the narrowed range at which it is possible for it to exist, the range being limited by the greater temperature differential between the burning surface and the water-cool interior of the various lumps of coal.

I present this argument merely as a supplement to the commendable article by Mr. Kuss, and do not wish to call his statement in question.

Menard, Ill. MARVIN WHITE

Why All the Dirt in Elevator Hoistways?

TO ANY ONE familiar with the rigid laws against fire hazards in the larger metropolitan areas, it is surprising to see how many dirty elevator hoistways exist. Bottoms are littered with combustible materials, steelwork is greasy and lint covered, and cables carrying electrical control circuits may be so oil-soaked that they give the impression of being ready to burst into flame at a moments notice.

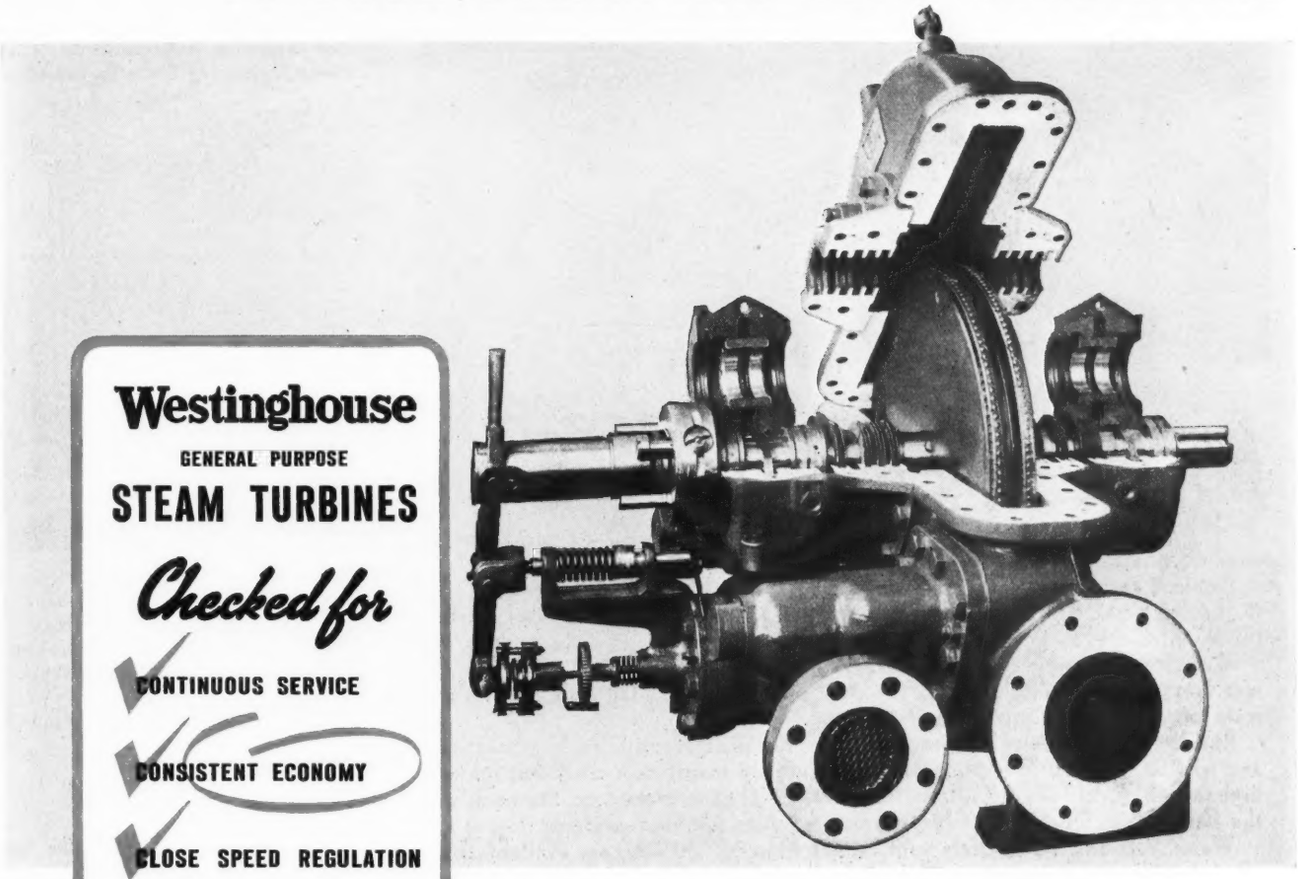
Similar conditions frequently exist in the machine rooms or pent houses. Oil-soaked waste and rags are often left lying around indiscriminately and doors and windows are left open to create drafts. The general appearance of machines and control boards gives one the impression, that other than being generally broken up and flooded with oil, they have been untouched by human hands since their original installation.

Such conditions exist mostly in buildings that are fire traps in themselves, due either to antiquated construction or the nature of the business conducted by the tenants.

Some one is responsible for the continuance of this hazard, whether it be through laxity or indifference. Who is it? The building-operating engineer, the owner, the insurance companies or the municipal authorities? It is hard to believe that this outstanding example of neglected maintenance does not have a counterpart in unsafe mechanical conditions.

Roanoke, Va. S H COLEMAN

Matched
TO YOUR STEAM AND LOAD CONDITIONS



Westinghouse
GENERAL PURPOSE
STEAM TURBINES
Checked for
- CONTINUOUS SERVICE
- CONSISTENT ECONOMY
- CLOSE SPEED REGULATION
- COMPLETE SAFETY

TO GIVE YOU LOWEST COST STEAM TURBINE POWER!

Economy in steam use requires that turbine nozzles and blades be matched to the conditions of the job.

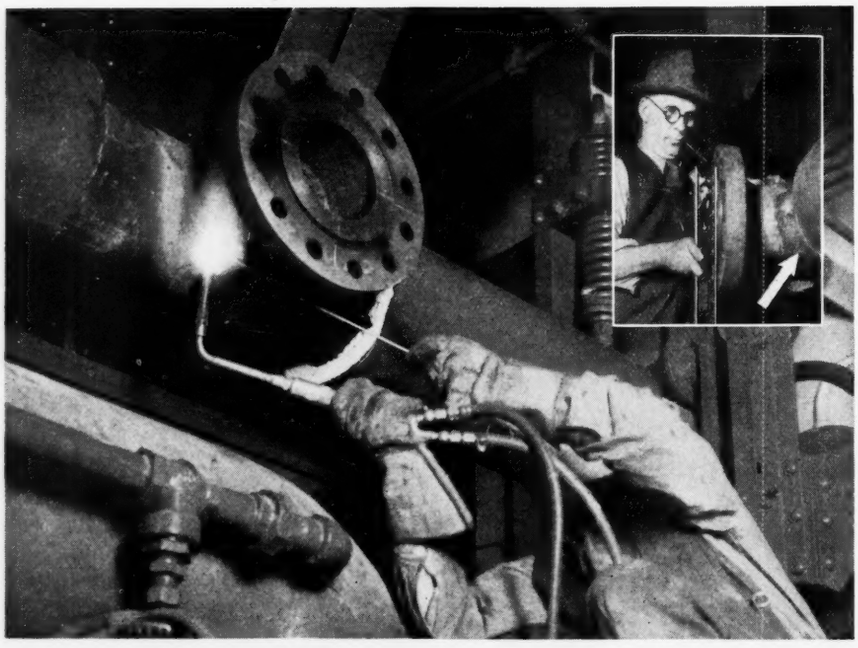
High or low-pressure steam — high or low exhaust pressure — high speed or low speed — Westinghouse nozzles and blades are specifically designed to meet your conditions of steam and load. Maximum economy is provided for each application — consistent economy over years of service can be assured.

Consistent economy is just one of four vital points in turbine design where Westinghouse General Purpose Turbines reflect the experience of 40 years of leadership in turbine engineering. *Investigate the others* — call your nearest Westinghouse office or write today for Booklet 2084-A, Westinghouse Elec. & Mfg. Co., Dept. 7-N, E. Pittsburgh, Pa.

J-50132

Westinghouse *Complete* STEAM AND STOKER SERVICE

TURBINES · CONDENSERS · FEED WATER HEATERS · VACUUM EQUIPMENT · STOKERS



For Maintenance—
BONNEY WELDOLETS·THREDOLETS

ON maintenance work, Bonney WeldOlets and ThredOlets prove their economy better than on any other type of job.

Pictured above is a 6" WeldOlet with flange being attached to an existing 8" boiler feed line. It would have required approximately 8 hours to remove the 8" line, cut, thread, insert a tee and replace it.

With the Bonney WeldOlet the main pipe stayed in position. The fitting was simply welded into place at the desired position and the hole cut in the main pipe, after the fitting was installed.

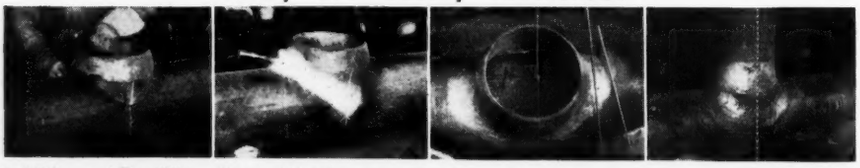
Result—an absolutely, leak-proof joint of full pipe strength, with turbulence and friction reduced to a minimum and savings in installation costs that run as high as 43%. The small illustration shows a square placed on the neck of the flange after installation. No warping or distortion was evident.

WeldOlets and ThredOlets with outlets from ¼" to 12" are available for all standard pipe sizes, in size-to-size or reducing sizes. Carried in stock of drop-forged steel. For special applications they are also furnished in Wrought Iron, Toncan Iron, Brass, Everdur, Monel, Stainless Steel, in fact any metal that can be forged.

Use them at a saving on your next maintenance job. In the meantime write for Bulletin WT23 telling How, When, Where and Why to use them.

The names "WeldOlets" and "ThredOlets" are Bonney trademarks registered in the United States Patent Office. Full patent coverage has been granted in the U. S. and foreign countries.

They are easily installed!



WeldOlets and ThredOlets are quickly and easily installed. Select the position of the outlet anywhere on the main pipe, mark center lines and tack the fitting into position.

Then weld by electric-arc or oxy-acetylene method. A leak-proof joint of full pipe strength is obtained.

On two-inch outlets or larger the button is removed after installation. A full inspection of the inside of the joint is possible when WeldOlets and ThredOlets are used.

A simple Vee weld is used for attaching the branch when WeldOlets are used. If ThredOlets are used, the branch is screwed into position.

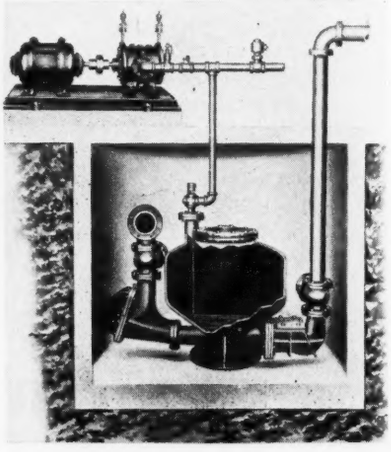
BONNEY FORGE & TOOL WORKS-Allentown, Pa.
WELDOLETS·THREDOLETS
. . . Welded Outlets for Piping . . .
Stocked by Leading Distributors

New Equipment

(*Continued from page* 112)

Sewage Ejector

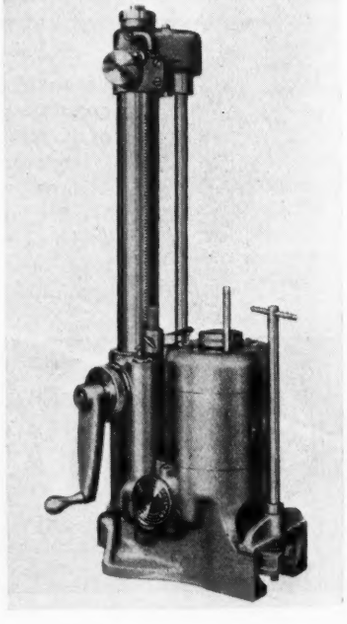
TYPE SEC "Shone" electrically-operated ejector for large buildings, booster stations, municipal sewage systems, and for heavy liquids in industry, uses compressed air to eject sewage. Air is admitted to ejector when pot is filled, and is shut off when pot is discharged by stationary electrical contacts. Unit is unique in that it has no float or bells, air tank, float switches, stuffiing boxes, or moving parts on or inside injector. Otherwise, operation is same as conventional units.



Yeomans Bros Co, 1433 Dayton St., Chicago, Ill.

Portable Boring Bar

"PER-FECT-O" No. 777 will take large cuts at high speeds, yet is light enough for one man to handle. Will bore or sleeve any diameter from 2.6 to 5.343 in., and has ample power throughout range from ½-hp. capacitor motor. Machine



TERRY

TERRY TURBINES GIVE SCHAEFER BREWING LOWER POWER AND PROCESS STEAM COSTS!

The two 500 KW Terry turbo-generator units shown above together with two Terry turbine driven refrigeration units were recently installed by the F. & M. Schaefer Brewing Company of Brooklyn, N. Y.

The installation not only gives the plant additional capacity but also enables it to develop all its power from process steam at a very low cost. Previously most of the exhaust steam had to be thrown away since it was contaminated with oil.

The refrigeration units are of the centrifugal type and are direct connected to the Terry drives (one 500 HP and one 650 HP). These drives as well as the turbines on the generator units are of the condensing bleeder type so that just the right amount of steam at 50 lbs. pressure can be extracted for use in the processing of beer. The power is therefore obtained as a by-product of the bled steam. The steam is clean and free from oil.

The installation is unusually flexible so that the power and process steam loads are handled efficiently. All of which results in lower power costs and a good heat balance.

A Terry installation may effect similar savings for you. We will be pleased to submit recommendations.

T-1126

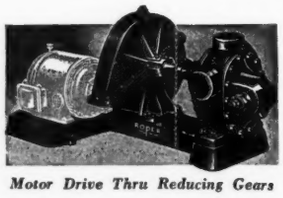
THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.

Smooth PERFORMERS!

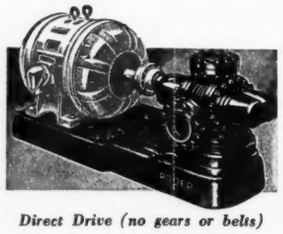
To qualify as smooth performers both equestrienne and steed must have perfect coordination, absolute balance and indefectible rhythm to successfully scale the barrier.

Good pumps also require perfect coordination, absolute balance and indefectible rhythm . . . otherwise they are not good pumps. Any pump not having these qualities will thrash itself to pieces long before its time. To be sure of smooth performers, why not put your faith in pumps that have licked every conceivable kind of job for over 80 years . . . pumps that are bear-cats for work and long life . . . pumps you can rely on always! Roper Pumps have exactly that record and reputation . . . use them wherever DEPENDABLE pumps are needed.

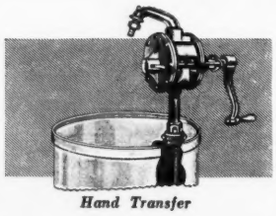
Write for Bulletin P-1. Geo. D. Roper Corp., Rockford, Ill.



Motor Drive Thru Reducing Gears



Direct Drive (no gears or belts)



Hand Transfer

ROPER Rotary PUMPS

DEPENDABLE - SINCE 1857

is complete unit, has two feeds and two speeds, takes 0.05 in. cut at any diameter within its capacity. Heavy-duty tool bits are standard equipment. Heavy-duty gears are totally enclosed and life-lubricated.

Van Norman Machine Tool Co, Springfield, Mass.

Roof Ventilator

FAN roof ventilator uses standard De Bothezat Type L fan with non-overloading power characteristic. Totally-enclosed, ball-bearing motor designed for vertical operation. Fan ring and motor

are mounted on vibration dampers to eliminate noise and vibration. Made in sizes ranging from 14- to 48-in. fan diameter. Bulletin DRV-L.

American Machine & Metals, Inc, De Bothezat Ventilating Equipt Div, 100 6th Ave, New York, N. Y.

Self-Locking Screw Thread

"RELIEVED PROFILE" thread, illustrated in locked position, has root of each bolt thread stepped at midpoint and each step is tapered 6 deg with axis of screw. Lower step is undercut 0.003 to 0.005 in., depending on nominal thread diameter, in contrast to original Dardelet thread which has continuous tapered slope on

bolt thread root without any step. Tapered crest of nut thread remains the same. Clearance exists between assembled bolt and nut threads, permitting limited axial displacement which provides for change in relative thread positions from unlocked to locked.

Dardelet Threadlock Corp. 55 Liberty St., New York, N. Y.

An important advance in valve design

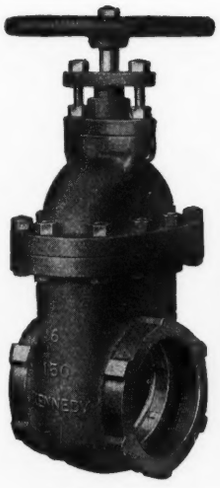


Fig. 057
Non-rising stem valve with screwed ends.

Fig. 058
Non-rising stem valve with flanged ends.

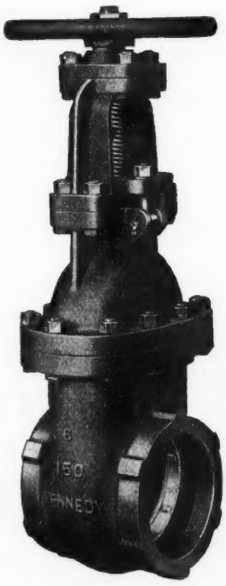


Fig. 0601
Rising stem and yoke valve with screwed ends.

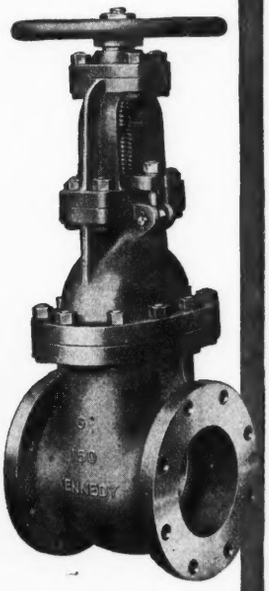


Fig. 0611
Rising stem and yoke valve with flanged ends.

Standard Iron-Body Wedge GATE VALVES with....

. . . . . literally a host of special features that make these valves easy to operate, resistant to destructive influences, thoroughly dependable, and economical to maintain. Every part from handwheel to pipe ends is designed to meet the most exacting requirements, and many of the refinements of these new valves are unobtainable in any other design.

If you want to know . . . .

how the stems are protected from scoring
why the stuffing box bolts cannot get in the way or their nuts and washers become lost while repacking
how stems are prevented from side motion when starting to open the valves
how annoyance of broken studs and difficulties of handling bolts and nuts are eliminated
how time is saved in connecting up to pipe lines
what is the unique packing arrangement that retains its tightness with either steam or water
why the stuffing box bolts and nuts cannot stick together
. . . and the remainder of the 33 special features that make these valves the best value on the market—

Write for Bulletin in which These Features are Fully Described

THE KENNEDY VALVE MFG. CO., ELMIRA, N. Y.

KENNEDY

Iron-Body *Wedge* Gate Valves

For ACCURATE Measurement

SIMPLEX
VENTURI TYPE
METERS

Simplex, type MO, Meter Register

- **Economical plant operation demands the keeping of reliable flow records of all plant functions. SIMPLEX VENTURI TYPE METER REGISTERS provide an accurate, sensitive means of obtaining such records.**
- **Sturdy in design, built for wide range service, Simplex Meters are selected by the discerning engineer for boiler feed, steam, condensate or evaporate flow measurement.**
- **Simplex Meters can be furnished in any size and for operation under working pressures up to 2500 pounds.**
- **Let Simplex Engineers help you with your metering problems.**

Write for Bulletin 42-A

SIMPLEX VALVE AND METER COMPANY
6780 Upland Street **Philadelphia, Pa.**

Readers' Problems

(*Continued from page* 93)

the plant. By reducing the moisture condition and by providing a good protective coating, trouble with sash should be eliminated.

Richmond, N Y C H HUGHES

Rust Removal Is Important

EXPERIENCE in bridge painting for a State Highway system leads to the conclusion that if you get all the rust off, and prime with red lead, you can use any paint you please. This highway department first used a graphite paint but abandoned it because of color. They then used a cream: 12 lb of carbonate white lead paste, 8.75 lb zinc oxide paste, 1 gal. raw linseed oil, and a little lamp black to color. About ½ pt of dryer was put in just before using. The department is now using aluminum paint over the red lead.

There is absolutely nothing to do but scrape the rust off, by any practical means, as it is useless to paint iron that has rust on it. The rust will continue to grow under the pretty coat of paint and it is only by close observation that the damage can be detected before the paint actually flakes off.

Leesville, S C F E BRODIE

Handy Paint Remover

IF ECM HAS a portable electric drill, circular wire brushes may be procured, locked between nuts on one end of a stud, and the other end of the stud inserted into the drill chuck. With this outfit, simple to make and use, all loose paint and rust may be removed. Wherever paint adheres firmly to the metal, hand scraping may be necessary, or if a small electric hammer is available, it may be fitted with chisels turned on one end to match the socket of the hammer and sharpened to the curvature of the frame.

Red lead, mixed with linseed oil and well thinned with dryer, makes an excellent priming coat. It is well to remember that two thin coats are better than one thick one. The final coat depends on individual preference, but enamel paints should not be used under wide variations of temperature, especially under conditions described by ECM.

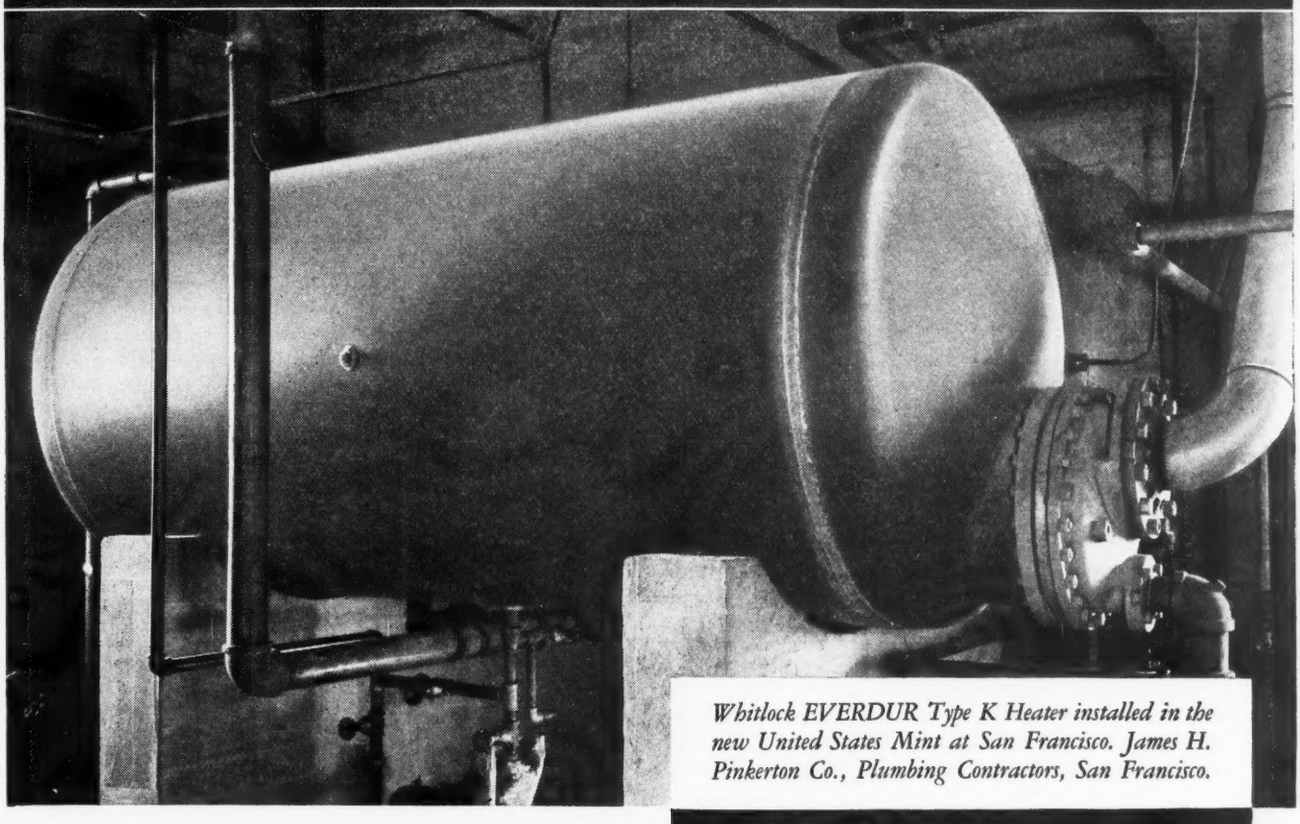
Menard, Ill. MARVIN WHITE

Recommends Three-Coat Job

ECM FAILS to state whether the glass in the sash is supported by steel mouldings, or by wire clips and putty. If steel mouldings are used, old paint can be removed by a good paint solvent. If putty is used, remover should not be applied as it destroys the bond in the putty, causing it to crack and fall out.

The overwhelming choice for non-rust heater tanks

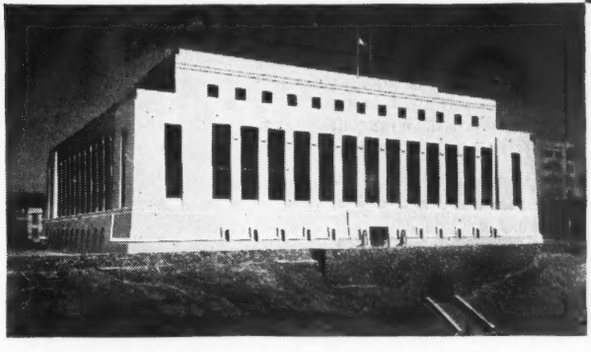
EVERDUR SILICON BRONZE



Whitlock EVERDUR Type K Heater installed in the new United States Mint at San Francisco. James H. Pinkerton Co., Plumbing Contractors, San Francisco.

COMPARATIVELY UNKNOWN ten years ago, Everdur has become the best known and most widely used non-rust tank metal. This high strength, corrosion-resistant silicon bronze alloy has properties which make it ideal for tanks of all sizes and types. Strong as steel, completely immune to rust and even more resistant to general corrosion than copper, Everdur is readily weldable by all commonly used methods.

Add to these qualities the fact that Everdur is reasonable in price, and it is apparent why this metal has become the overwhelming choice for non-rust heater tanks.



For all types of industrial and commercial installations, for schools, colleges, clubs, laundries, hospitals, and private homes—non-rust Everdur storage heaters are obtainable from leading equipment manufacturers. 3896

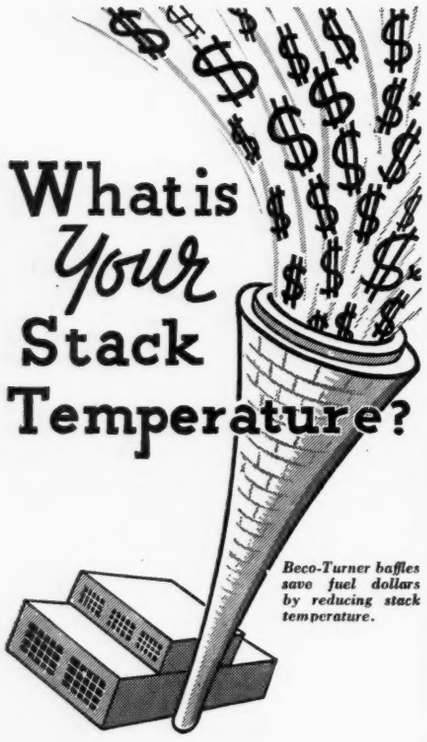
ANACONDA
from mine to consumer

Everdur SILICON BRONZE

THE AMERICAN BRASS COMPANY, General Offices: WATERBURY, CONNECTICUT

Offices and Agencies in Principal Cities • In Canada: ANACONDA AMERICAN BRASS LTD., New Toronto, Ont.

"EVERDUR" is a trade-mark of The American Brass Company, registered in the United States Patent Office.



What is Your Stack Temperature?

Beco-Turner baffles save fuel dollars by reducing stack temperature.

Don't let leaky, inefficient baffles waste your fuel

EVERY B.T.U. that goes up your stack represents lost fuel value. Is your stack belching wasted dollars into the air in the form of excessive flue gas temperatures?

If the temperature of your boiler exit gases is excessive, the likelihood is that the baffles are leaky, or inefficient in design, or both, and it will pay you to investigate Beco-Turner baffles.

Beco-Turner baffles are positively gas tight due to the flexibility provided by their patented expansion joints. In each installation, they are designed to put into practice the most modern developments in baffle and furnace design.

Every operator of water tube boilers should read the Beco-Turner catalog. Mail coupon below for your free copy. If you will send blueprints showing your existing baffles, we will gladly submit any possible recommendations for reducing stack temperature and saving fuel through improved baffle design.

Plibrico Jointless Firebrick Co.

Nation-Wide Boiler Setting Service

Baffle Dept., Chicago, Ill.

BECO-TURNER BAFFLES

Plibrico Jointless Firebrick Co. P4-38
1818 Kingsbury St., Chicago, Ill.
Please mail copy of Beco-Turner catalog.

Firm .....

Address .....

.....

Name..... Title.....

Scraping and wire-brushing is the only solution, in this case.

After all loose paint is removed, a first coat should be applied, using a paint composed of 12.5 lb of red-lead paste, reduced with 3 qt of synthetic waterproof varnish. For the second coat mix 6 lb of red-lead paste and 5 lb of titanium-oxide paste, again reducing with 3 qt of varnish. For the third coat, use 2 lb of aluminum powder or paste, to 1 gal. synthetic waterproof varnish. If it is necessary to hold down the cost, leave out the third coat, and make the second coat the same as the first with the addition of a little lampblack to color. The 3-coat job has the advantage of being lighter in color, and much more durable. The added expense will be justified by the results. In applying the paint to the sash, it should be allowed to extend out on the glass about $\frac{1}{16}$ in. to cover the joint.

Flushing, N. Y. J J BALL

Glyptal Varnish Solves Rust Problem

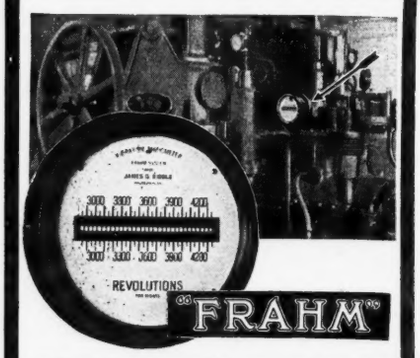
STEEL SASH in the armature-winding shop of a friend of mine continually rusted due to condensation from air which had been humidified. Repeated paintings failed to cure the condition until I suggested glyptal varnish, used on electrical equipment to resist moisture, oil, acids, and alkalies. The sash was cleaned with paint remover and

BRAIN TESTER

Answer to problem on page 92

TO MEASURE one gal., Bill filled the 5-gal. can from the tank, then filled the 4-gal. can from the 5-gal. can, leaving *one gal.* So far it was easy. He then poured the 7-gal. can full and filled the 5-gal. can from it, leaving *two gal.* Still easy. The same trick, but using the 7-gal. can and the 4-gal. can, gave him *three gal.*, and of course he got *four gal.* directly by filling the yellow can. It was just as simple to get *five gal.* using the blue can. Measuring out 6 gal. proved a little harder, but by filling the 7-gal. can from the tank, then filling the 5-gal. can from it, he had 2 gal. left in the red can. Dumping the contents of the 4-gal. can, just filled from the tank, into the red can gave him *six gal.* in the red can.

Bill got another breathing space on *seven gal.* since the red can measured it out without any fooling around. From then on, he had to work. First, to measure 8 gal., he filled the 4-gal. can, pouring its contents into the blue 5-gal. can. Refilling the 4-gal. can gave him *eight gal.* half in the blue can and half in the yellow. Getting *nine gal.* proved easier, since all he had to do was to fill the 5-gal. can and the 4-gal. can from the tank. On the last lap, and with the possibility of winning his bet staring him in the face, he filled the 5-gal. can from the tank, quickly dumped the contents into the red can, filled the 5-gal. can again, and yelled "pay me!"



VIBRATING-REED
TACHOMETERS

FRAHM Tachometers indicate r.p.m. by the vibration of tuned steel reeds. There are no rotating parts, no bearings, shafts, gears or belts; no springs, magnets or electrical connections; nothing to lubricate, nothing to wear or adjust. These simple, sturdy speed indicators

without rotating system or moving pointer

retain their original calibration for long periods, are easily mounted, require no servicing, cost little or nothing to maintain, give years of satisfactory service.

"Frahm" Hand Tachometer

Frahm Tachometers are widely used for permanent mounting on turbines, pumps, blowers, generators, motors, etc. Portable or hand types are exceedingly valuable on turbines and other enclosed machines; also for measuring strokes per minute of pneumatic hammers and drills.

Being *frictionless*, Frahm Tachometers are unique for measuring speeds of very small motors, where the ordinary type of Tachometer imposes a load and reduces the speed.

Speed ranges from 900 up to 30,000 r.p.m. For complete description send for Bulletin 1510-P.

JAMES G. BIDDLE CO.

ELECTRICAL INSTRUMENTS
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Other Biddle Specialties:

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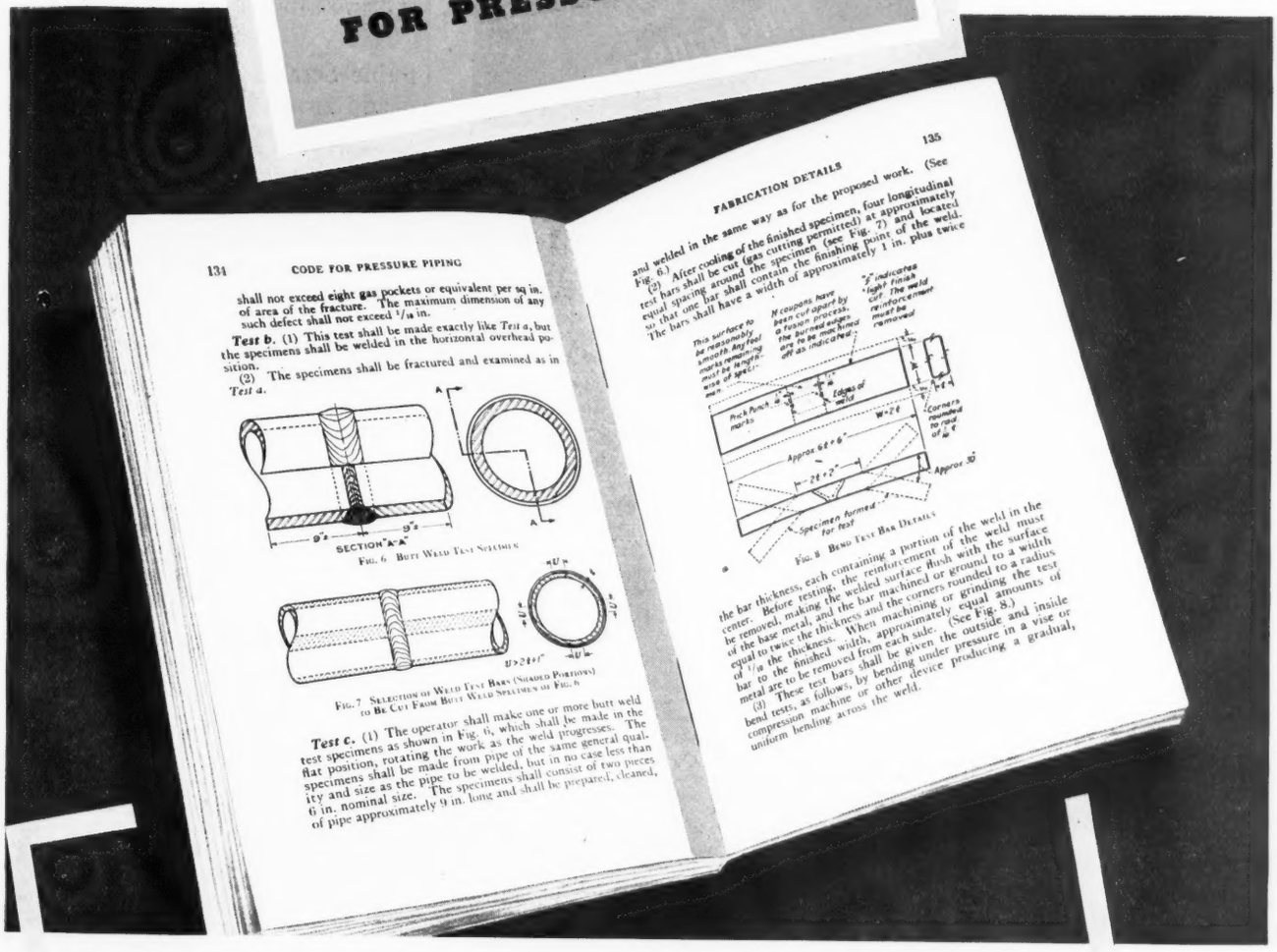
"Megger" Direct-Reading Ohmmeters
"Ducter" Low Resistance Testing Sets
"Dionic" Water Tester
"Frahm" Vibrating-Reed Frequency Meters
"Jagabi" Rheostats
"Jagabi" Speed-Measuring Instruments

Correct WELDING FOR PRESSURE PIPING



134 CODE FOR PRESSURE PIPING

shall not exceed eight gas pockets or equivalent per sq in. of area of the fracture. The maximum dimension of any such defect shall not exceed $\frac{1}{16}$ in.

Test b. (1) This test shall be made exactly like *Test a*, but the specimens shall be welded in the horizontal overhead position.

(2) The specimens shall be fractured and examined as in *Test a*.

SECTION "A-A"

FIG. 6 BUTT WELD TEST SPECIMEN

FIG. 7 SELECTION OF WELD TEST BARS (SHADED PORTIONS) TO BE CUT FROM BUTT WELD SPECIMEN OF FIG. 6

Test c. (1) The operator shall make one or more butt weld test specimens as shown in Fig. 6, which shall be made in the flat position, rotating the work as the weld progresses. The specimens shall be made from pipe of the same general quality and size as the pipe to be welded, but in no case less than 6 in. nominal size. The specimens shall consist of two pieces of pipe approximately 9 in. long and shall be prepared, cleaned,

135 FABRICATION DETAILS

and welded in the same way as for the proposed work. (See Fig. 6.)

(2) After cooling of the finished specimen, four longitudinal test bars shall be cut (gas cutting permitted) at approximately equal spacing around the specimen (see Fig. 7) and located so that one bar shall contain the finishing point of the weld. The bars shall have a width of approximately 1 in. plus twice

FIG. 8 BEND TEST BAR DETAILS

the bar thickness, each containing a portion of the weld in the center. Before testing, the reinforcement of the weld must be removed, making the welded surface flush with the surface of the base metal, and the bar machined or ground to a width equal to twice the thickness and the corners rounded to a radius of $\frac{1}{16}$ the thickness. When machining or grinding the test bar to the finished width, approximately equal amounts of metal are to be removed from each side. (See Fig. 8.)

(3) These test bars shall be given the outside and inside bend tests, as follows, by bending under pressure in a vise or compression machine or other device producing a gradual, uniform bending across the weld.

Users of welded piping for high temperature and/or high pressure service will find it advantageous to insist that their welding conform to the "welding procedure" and "qualification tests for welders" as given in the Code for Pressure Piping.

This Code is used as standard by qualified pipe fabricators, any one of whom will gladly answer questions about it and also explain the many advantages to the purchaser of using this Code as the standard for pipe welding and pre-fabrication.

Qualified pipe fabricators recognize the vast difference in the results accomplished by "qualified welders for pressure piping" and by "just welders." They also understand the importance of proper procedure and know that both are essential in assuring the high quality of their pressure welding.

The Pipe Fabrication Institute will gladly forward on request a copy of the Code for Pressure Piping at the established price of $1.00 per copy.

THE PIPE FABRICATION INSTITUTE

P.F.I. THE PIPE FABRICATION INSTITUTE

Devoted to the Technical and Economic Problems in Piping

1108 CLARK BUILDING
PITTSBURGH, PA.

Courtesy of Baldwin-Southwark Corp.

• clearances controlled—
• oil pressure maintained

On this diesel, LAMINUM babbitted shims (pat'd) are standard . . . for the important oil pressure control and precision adjustment of main and connecting rod bearing clearances. The same easy accuracy in service adjustments as in assembly! You simply peel off .002 in. (or .003 in.) laminations. Always a clean shim surface! Laminum sample on request.

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Precision adjustment **SHIMS**

SEAL-ALL
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JOINTING COMPOUND

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Just daub it on . . . replaces expensive gaskets — Won't blow out!

Cuts Labor and Maintenance Costs . . . Withstands Highest Pressures. Economy and lastingness proved by leading Power Plants, Ship Builders, Steamships, Railroads, U. S. Navy Yard . . . Public Utilities and wherever tightly sealed joints are vital.

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wire brushes and then repainted with two coats of General Electric No. 1170 varnish, clear. After reading ECM's question, I revisited my friend's shop and found the sash as glossy and smooth as when painted two years ago. If black is desired, G. E. No. 457 varnish has the same properties as the clear varnish.

Tenafly, N J K B HOFFMAN

Paint Scrapers Made from Files

A SCRAPER for removing paint and rust from sash can be made from an old file, by sharpening one end, and bending it back on itself about $\frac{1}{2}$ in. When the surface has been made clean and dry, a red lead, weighing about 22 lb to the gal., should be applied. After the priming coat is dry, the job can be finished with any reliable brand of black graphite paint. Sash troubles should be over for a number of years.

Norwalk, Conn C W MEEKA

Paint Vehicles Are Important

THE FIRST RULE of protective painting is that the surface must be absolutely clean. The old paint may be removed by a blowtorch (if it can be done without breaking the glass) or by commercial paint removers, and metal surfaces must be cleaned by scraping and wirebrushing until bright.

To make a really good protective coating, a 3-coat system is best. The priming coat should contain red lead or lead chromate. The intermediate coat should be a flat paint, and the final coat a durable paint with a glossy finish that will withstand moisture.

The vehicles used in the three coats must be suitable for use together, otherwise the coats will not adhere. For this reason, I feel it would be advisable for ECM to refer his problem to some reliable and experienced paint manufacturer.

Hamilton, Conada J R DUNBAR

What Happens to Sodium Sulphite?

(*Continued from page* 91)

Since this covered all losses, including continuous blowdown, 0.5% carryover and the requirements of oxidizing agents in the water, he concluded that the actual consumption of all reactions in the boiler water could scarcely be over 1 lb of sodium sulphite per day, even assuming no oxygen in the feedwater. If Straub's conclusions applied, it would be necessary to add at least 48 lb of sulphite per day, 20 times the amount actually used. Further tests will be made on this boiler to obtain a more complete operating picture.